THE GEOLOGY OF THE LOWER MESOZOIC ROCKS OF QUEENSLAND,

With special reference to their Distribution and Fossil Flora, and their Correlation with the Lower Mesozoic Rocks of other parts of Australia.

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(Plates i.-ii., and six Text-figures).

Contents.

Introduction, and Scope of the Paper.

In Eastern Australia and Tasmania there is no large development of rocks of marine origin, representing deposition during the period between the close of the Palæozoic era and the beginning of the Cretaceous period. During this interval, with a single exception, the sediments deposited in this region were of origin other than marine; the organic remains included in these rocks consist for the most part of plants, but, in addition, fish* and insects† are abundant on some horizons, phyllopods are represented by *Estheria*, and pelecypods by *Unio* and *Unionella*. The exception mentioned above is the upper portion of the Wianamatta Stage in New South Wales; the top of this stage is formed by a thickness of 100 feet of a calcareous rock, which contains a fauna of Ostracoda and Foraminifera. This fauna has been described by Chapman, whose conclusion regarding the species is as follows: "These undoubtedly represent a brackish or estuarine fauna, having a curious intermingling of Rhætic and Lower Jurassic types, with others more properly referable to the Upper Palæozoic of Europe."‡

The term "Lower Mesozoic" will be used throughout this work for these rocks; the name "Trias-Jura" has been generally used, but it is not a suitable one, and we have not been, up to the present, in a position to assign either a Triassic or Jurassic age definitely to all of them. The name Lower Mesozoic may be used generally to include the whole of these rocks, and to refer to all the strata in Eastern Australia which were deposited between the close of the Palæozoic era and the beginning of the Cretaceous period.

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* Woodward, Mem. Geol. Surv. N. S. Wales, Palæontology, Nos.4, 9, 10.

† Etheridge and Olliff, *ibid.*, Palæontology, No.7; Tillyard, Queensland Geol. Surv., Publication No.253.

‡ Records Geol. Surv. N. S. Wales, viii., p.335, 1909.

The correlation of these beds is necessarily based on the fossil plants, since they are the only remains which are of widespread distribution. In the past, fossil plants have formed a very uncertain means for the accurate correlation of strata. This has been due, particularly in the case of Australia, to imperfect study of the material available. This statement is not made to detract from the value of the work done by the earlier Australian geologists; we owe much to their efforts, for they did an immense amount of work under conditions much less favourable than those under which we work at the present time. The vastly improved conditions existing at the present day must always be borne in mind, when the work of the older geologists is under consideration; this point cannot be too strongly emphasised, for there is very often a tendency to forget or overlook it.

The author has just completed an examination of the fossil flora of the Queensland Lower Mesozoic strata,* and the present paper is concerned chiefly with a discussion of the results of that examination.

Briefly stated, the object of this contribution to Australian Geology is to attempt to place the correlation of the Lower Mesozoic rocks of Australia on a sound basis. The paper aims at :

(*a*) Dealing in a fairly comprehensive manner with the general characters and distribution of the Lower Mesozoic rocks of Queensland.

(*b*) A critical discussion of the relations of the flora of these rocks.

(*c*) A comparison and correlation of the Lower Mesozoic rocks of Queensland with other Lower Mesozoic rocks of Australia, paying particular attention to the relations of the fossil floras of the various occurrences to one another.

(*d*) The determination of the position of the Australian Lower Mesozoic rocks in the Geological Record. And

(*e*) A discussion of the palæogeography of the Australasian region during Lower Mesozoic time.

* Queensland Geol. Surv., Publications Nos.252, 257, 259.

It may be of advantage here to summarise the present position of our knowledge of the floras of Australian Lower Mesozoic rocks.

Rocks of this age are developed in all the Australian States, but only in Western Australia are they of marine origin. The state of our knowledge of the fossil floras cannot be considered satisfactory. In Western Australia, the number of plants in these rocks is very small, but the fact, that they are associated with strata containing marine fossils, is of great importance as giving some indication regarding their exact position in the Geological Record. In South Australia, a few fossil plants have been described from the Lower Mesozoic rocks at Leigh's Creek, and *Phyllopteris Feistmanteli* has also been recorded from Ooroowilanie Swamp, 100 miles north of Leigh's Creek; this latter record may be from the Cretaceous rocks overlying the Rolling Downs Series. In Tasmania, fossil plants are abundant, and a large number have been described and figured from Lower Mesozoic rocks. Unfortunately, some of the determinations are open to doubt, and many of the figures and description are too imperfect to be of value in a comparison of the Tasmanian Mesozoic flora with other Australian Mesozoic floras In Victoria, Lower Mesozoic rocks occur in three areas (South Gippsland, Cape Otway, and Wannon areas). A collection of fossil plants from these strata has been described by Professor Seward, and more recent additions have been determined by Mr. F. Chapman. This flora has been determined as of Jurassic age, and it is sufficiently well-known to enable reliable comparison to be made with other floras. In New South Wales, fossil plants are abundant in Lower Mesozoic rocks, but no comprehensive examination of the whole flora has been undertaken. Lists of the floras of the different Series, prepared by Mr. W. S. Dun, were published in Carne's memoir on the Western Coalfield of New South Wales, in 1908. These have been supplemented, from time to time, by descriptions of additional specimens, by Mr. Dun. From these lists, it is possible to obtain a fairly good idea of the flora of the Lower Mesozoic rocks in New South Wales. In Queensland, the author has just completed an examination and revision of the floras of the Ipswich and Walloon Series, the results of which have been published by the Queensland Geological Survey.

The correlation of the Lower Mesozoic rocks of Australia (based mainly on their fossil floras) and their exact position in the Geological Record have been the subject of much discussion, and different views regarding their correlation have been put forward from time to time. In a summary of the literature dealing with the Queensland Lower Mesozoic rocks,* I have already briefly summarised the majority of these views, and there is no need to discuss them in further detail here. It is sufficient to state that no finality has been reached on this point, and, in many cases, conclusions have been based on insufficient evidence.

As a result of my examination of the Queensland fossil flora, together with a consideration of the evidence of the fossil faunas, and, in addition, general considerations of the strata containing the fossils, certain conclusions regarding the correlation of the various series have been arrived at (see p.95) which differ from any previously put forward.

Acknowledgments.

It is almost impossible to express the extent of my indebtedness to Mr. B. Dunstan, Chief Government Geologist of Queensland, in connection with the whole of my geological and palæontological work in Queensland. He has placed at my disposal every facility for examining the large collection of Mesozoic plants in the possession of the Geological Survey; in addition, he has made available to me a very considerable amount of unpublished information, and permitted me to use such for the purpose of making this paper as complete as possible. In the section of this paper dealing with the extent and distribution of the Lower Mesozoic rocks, much field-information is published for the first time, and this is based almost entirely on information supplied by Mr. Dunstan. I would like, therefore, to make special acknowledgment of my indebtedness to Mr. Dunstan,

* Queensland Geol. Surv., Publication No.252, p.6.

and to place on record my appreciation of the generous way in which he has lent me all possible assistance.

To other officers of the Geological Survey, I am indebted for their willingness to assist me with their knowledge of these strata in the field, especially Mr. W. E. Cameron, who has made such a detailed study of the Ipswich Series in the Ipswich Coalfield, and who has given me access to the information which he has obtained for the preparation of his third report on this field.

For assistance in connection with the geology of the Lower Mesozoic rocks in Western Australia, South Australia, and Tasmania, I have to thank Messrs. A. Gibb Maitland, L. K. Ward, and W. H. Twelvetrees, respectively.

To Professor David, I owe my introduction to the broader problems of Australian Geology, and the resulting desire to assist in the solution of some of the problems of Australian stratigraphy. I have been inspired to carry out the palæo-botanical portion of my work as thoroughly as possible, by the kindly encouragement of Professor Seward.

I am indebted to the authorities of the University of Sydney for permission to publish this paper.

Previous Literature.

Most of the papers dealing directly with the subject of the Lower Mesozoic rocks of Queensland, or their flora, have already been briefly summarised in an earlier paper, but there are a few additional papers to which reference may be made here.

Mr. C Hedley, in his Presidential Address to Section D of the Australasian Association for the Advancement of Science in 1909, published two maps of the Queensland region in Mesozoic time, one reproduced after Neumayr, showing the distribution of land and water in Triassic time; and the other original, showing the same at the close of the Mesozoic Era.

Dr. H. I. Jensen, in a paper entitled "The Building of Eastern Australia,"* has many references to the Lower Mesozoic rocks. The paper partakes rather of the nature of a summary of views

* Proc. Roy. Soc. Queensland, xxiii., Pt. 2, 1912, p. 149.

the author stating in his introduction that the object of the paper "is not to offer the reader any really new material, but rather to present the knowledge we already possess in a concise form . . . ." Nevertheless, many interesting points are raised, one or two of which bear more particularly on the problem of the Lower Mesozoic, and these will be referred to later. A series of maps accompanies the paper, showing suggested distribution of land and sea in the Australian region during the various geological periods.

Mr. E. C. Saint-Smith has carried out extensive observations on the Lower Mesozoic rocks in the Roma District, and presented a summary of his results* to the Second Interstate Conference on Artesian Water. These observations cover a very large area of Lower Mesozoic rocks, and fossil plants were found at various localities. The present author had the pleasure of accompanying Mr. Saint-Smith on a reconnaisance-trip over part of the area between Yeulba, Goongarry (Hornet Bank Station), and Roma, and can confirm Mr. Saint-Smith's remarks regarding the strata of that area. The greater part of the country traversed consists of outcrops of sandstones, with, here and there, shales and coal-seams, belonging to the equivalents of the Walloon Series.

Professor David, in the Federal Handbook for the Meeting of the British Association for the Advancement of Science in Australia in 1914, refers briefly to the Lower Mesozoic rocks of Queensland, which he classes as Jurassic.

Mr. R. J. Tillyard has described a number of fossil insects, from Lower Mesozoic rocks in Queensland and New South Wales.† The majority of the insects were obtained from Denmark Hill, Ipswich, in strata belonging to the Ipswich Series, and others from St. Peter's, near Sydney, N.S.W., from the Wianamatta Stage of the Hawkesbury Series. Twenty-two species were described from the Ipswich Series, and six species from the Wianamatta Beds.

The insects appear to be of considerable interest from the

* Rept. Second Interstate Conference on Artesian Water, Brisbane, 1914, p.19.

† Queensland Geol. Surv., Publication No.253.

point of view of the phylogeny of the Insecta, but the results, up to the present, do not indicate that they will be of material value in the determination of horizons, or in fixing the position of the strata in the Geological Record.

In Appendix B to the "School Geography of Queensland," by G. Harrap, published in 1916, Mr. Dunstan gives a new classification of the geological formations of Queensland In this classification, the Lower Mesozoic rocks are divided into (?)Triassic and Jurassic, the Ipswich Series and Bundamba Series being classed as (?)Triassic, and the Walloon Series as Jurassic. No definite evidence is given for the separation. Included also in the Jurassic are the trachytes of the Glasshouse Mts., which all recent work goes to show are of Cainozoic age.

Professor Schuchert, in a paper recently issued, entitled "The Problem of Continental Fracturing and Diastrophism in Oceanica,"* gives a series of palæogeographic maps of Oceania; these include one showing the distribution of land and water in the Triassic period.

Mr. E. C. Andrews, in a recent paper entitled "Notes on the Structural Relations of Australasia, New Guinea, and New Zealand,"† makes many statements which invite criticism, some of them coming within the scope of this paper. He considers the growth of Australia, New Guinea, New Caledonia, and New Zealand as independent units. The question suggests itself—Are not these portions of the one continental mass, which have become separated as a result of folding-movements? In discussing the Trias-Jura, he infers two basins of deposition in New South Wales and Queensland, viz.: the Hawkesbury basin, and a northern basin, separated by high land-barriers, and with sedimentation taking place simultaneously in the two basins.

There are many papers dealing with the volcanic rocks of south-eastern Queensland, in which passing reference is made to the Lower Mesozoic rocks occurring in the same area as the volcanic rocks. It is unnecessary to mention these in detail

* Amer. Journ. Sci., xlii., 1916, p.91.

† Journ. Geol., xxiv., 1916, p.751.

here; such papers include the works of Jensen, Wearne and Woolnough, and Richards, in addition to the publications of the Queensland Geological Survey.

The Lower Mesozoic Rocks of Queensland.

(*a*) *General.*—Until quite recently, the Lower Mesozoic rocks of Queensland have been officially designated "Trias-Jura." This name was first used in 1892, it being suggested that the Burrum and Ipswich Formations represented a period of time extending from the base of the Trias to the top of the Oolite.* Prior to that date, in 1888, regarding the Ipswich and Burrum Formations, Jack says† "The Burrum Coalfield is plainly on a higher horizon than the Bowen River field [Permo-Carboniferous]. It contains a fossil flora in which many plants are common to the Mesozoic Ipswich Formation, and also, it is said, *Glossopteris* with a very meagre fauna, most of it peculiar to the coalfield." . . . . . "Probably to call it Triassic would not be very far from the mark, in at least a homotaxial sense." In the same paper, speaking of the Ipswich coalfield, he says "The coalfield contains an abundant fossil flora of a strongly Jurassic facies, and is probably the equivalent of the Clarence River beds of New South Wales."

It appears, then, that the recording of *Glossopteris* in the Burrum Formation was originally responsible for its being regarded as older than the Ipswich Formation. There is, however, no authentic record of the presence of *Glossopteris* in the Burrum Series.

When the two formations were united, in 1892, as the Trias-Jura, the Burrum Formation was regarded as Lower, and the Ipswich Formation as Upper Trias-Jura.‡ Ten species of plants were described by Etheridge from the Burrum Formation, and thirty-one from the Ipswich. The two formations were not known in contact in the field, so there was no stratigraphic evidence as to their relation to one another, and this had to

* Geology and Palæontology of Queensland, 1892, p.312.

† Report Aust. Assoc. Adv. Sci., i., 1889, p.196.

‡ Geology and Palæontology of Queensland, 1892, p.312.

be determined from the contained fossil plants. The fossils, which were available from the Burrum Formation at the time, were, unfortunately, fragmentary, and were not a representative collection. Further collections have been obtained from time to time since, and a cursory examination of the material now available in the Geological Survey collections shows distinct differences from the floras of the Ipswich and Walloon Series. It is intended that an examination of the Burrum flora will be undertaken after the completion of the present paper.

In 1907, Mr. Cameron, in discussing the age of the Ipswich Formation, says* "The evidence for considering the Burrum Beds as belonging to an earlier period of the Trias-Jura is not conclusive. The two formations have long been considered as identical in age by the Geological Survey, and the recent observations of Mr. Jensen lend confirmation to that conclusion."

Our present knowledge shows that a large part of what was, at that time (1907), regarded as part of the Burrum Formation, is actually a continuation of the upper series of what was considered then as the Ipswich Formation. Dr. Jensen had recorded the fact that these were continuous in the field in the neighbourhood of Point Arkwright.†

The question of the age and extent of the Burrum Formation has, however, been established beyond doubt by the observations in the field of Mr. Dunstan. As a result of these observations, it is now certain that the Burrum Series, in the Maryborough-Howard district, overlies, with apparent stratigraphic conformity,‡ rocks of marine origin, whose contained fossils indicate a Cretaceous age, probably equivalent to the Rolling Downs Formation of Western Queensland. Mr. Dunstan has also shown that the strata to the south and south-west of Maryborough, originally mapped as part of the Burrum Formation, dip towards the north-east beneath the marine Cretaceous rocks, and are equivalent to the Walloon Series. For these equivalents of the

* Queensland Geol. Surv., Publication No.204, pp.12, 13.

† Proc. Linn. Soc. N. S. Wales, 1906, xxxi., pp.74-75.

‡ Ann. Rept. Dept. Mines, Queensland, 1911 (1912), p.195; Queensland Govt. Mining Journ., xiii.(1912), p.641.

Walloon Series in this area, Mr. Dunstan has proposed the name "Tiaro Series."*

Of the two formations which were united to form the so-called Trias-Jura System, then, one has been removed into the Cretaceous System, and the remaining one (the Ipswich Formation) is that which was originally regarded as the probable equivalent of the Jurassic System.

The Ipswich Formation was divided into three Series by Mr. Cameron, viz.: Ipswich Series, Bundamba Series, and Walloon Series. The use of the terms Ipswich Formation and Ipswich Series (part of the Ipswich Formation) has probably led to a certain amount of confusion, but the removal of the Burrum Formation to the Cretaceous System renders the use of the name Ipswich Formation superfluous, and it would be an advantage to abandon it.

(*b*) *Geological Succession.*—The Lower Mesozoic rocks of Queensland consist of three Series, viz.:—

3. Walloon Series (Upper).
2. Bundamba Series (Middle).
1. Ipswich Series (Lower).

The complete succession is found only in South-eastern Queensland, where a considerable amount of detailed geological work has been carried out, chiefly because both Ipswich and Walloon Series contain workable coal-seams.

The Ipswich district has been examined in detail by Mr. Cameron, who has published two reports on the area,† and is preparing a third, incorporating the results of recent developments in the district.

South-east Moreton has been the subject of investigation by Mr. E. O. Marks, late of the Queensland Geological Survey, whose results are embodied in a publication entitled "The Coal-Measures of South-east Moreton."‡ The examination of the continuation of the Coal-Measures, from the area examined by

* See Rept. Second Interstate Conference on Artesian Water, Brisbane, 1914, p.7.

† Queensland Geol. Surv., Publications 147, 204.

‡ Queensland Geol. Surv., Publication 225.

Mr. Marks towards the New South Wales border, has been commenced by Mr. J. H. Reid, of the Geological Survey.

Other areas of Lower Mesozoic rocks in Queensland have been studied in detail by other officers of the Geological Survey, the more important ones being: the Stanwell Coal-Measures, examined by Mr. Dunstan;* the Laura Coalfield, west of Cooktown, by Mr. Ball;† the Lower Mesozoic rocks in the Roma district, by Mr. Saint-Smith. Unfortunately, the full results of Mr. Saint-Smith's work have not been published, but a summary was communicated to the Second Interstate Conference on Artesian Water.‡ For local details regarding these areas, reference must be made to these publications.

(*c*) *Lithological Characters.*—The lithological characters of the Lower Mesozoic rocks in Queensland do not call for very special remark. For the greater part, they consist of sandstones and shales in varying proportions, with which are associated occasional conglomerates, grits, and also coal-seams.

The Ipswich Series consists, for the most part, of light-coloured shales and sandstones, with associated conglomerates, and fourteen or fifteen workable coal-seams. There are coarse conglomerates developed near the base of the series, indicating vigorous erosion in the early portion of the period.

The Brisbane Tuff, which is near the base of the Ipswich Series in the Brisbane area, is a rock probably of volcanic origin (though there is no indication of its source), resulting from the deposition of volcanic ash of acid nature over a long, narrow area in the vicinity of Brisbane. The general direction of the outcrop of this belt of tuff is N.30°W. As far as known, there are no volcanic rocks of undoubted Lower Mesozoic age in South-eastern Queensland, with the exception of a series of andesites south of Maryborough, which are apparently interbedded in the Tiaro Series. Marks, Andrews, and Wearne and Woolnough have, at times, advocated a Lower Mesozoic (Trias-Jura) age for

* Queensland Geol. Surv., Publication 131.

† Queensland Geol. Surv., Publication 222, p.5.

‡ Report Second Interstate Conference on Artesian Water, Brisbane, 1914, p.19.

some of the South-east Queensland volcanic rocks, but Dr. Richards has recently examined all their evidence* and shown that, in each case, there is no doubt that the volcanic rocks are of Cainozoic age. Since then, Mr. Dunstan has placed the volcanic rocks of the Glasshouse Mountains in the (?) Walloon Series;† the only field-evidence regarding the age of these rocks is that they are intrusive through a series of sandstones, which Mr. Dunstan believed, at the time, to belong to the Ipswich Series. On the evidence of the relationship between these volcanic rocks and other volcanic rocks of South-eastern Queensland, their age certainly seems to be Cainozoic. Some of the beds of the Ipswich Series at Denmark Hill, Ipswich, are regarded by Mr. Dunstan as tuffaceous in character.‡

The Bundamba Series, which succeeds the Ipswich Series, consists, for the most part, of massive sandstones. With the exception of one coal-seam about 1 foot, 6 inches thick, known as the West Moreton seam, they have proved unproductive of coal; they are also practically barren of fossils, the only record being of silicified wood. The basal portion of the Bundamba Series lies about seventy feet above the top seam (Aberdare seam) in the Ipswich Series, and consists of coarse grits and conglomerates.

The Walloon Series, lithologically, is of somewhat similar nature to the Ipswich Series. In consists mainly of comparatively soft sandstones, with which are interbedded fine-grained shales and coal-seams. Conglomerates are developed, but are of limited occurrence. The soft sandstones and shales weather away rapidly, and, consequently, in many places, outcrops are few and inconspicuous.

In the Stewart's Creek (Stanwell) district, the Series includes a hard, white, siliceous tuff in which abundant fossils are preserved.

A remarkable feature in the Walloon Series is the very wide-

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* For summary of evidence, *see* Proc. Roy. Soc. Queensland, xxvii. (2), 1916, p. 126.

† Harrap's School Geography of Queensland, Appendix B, p 167,

‡ Queensland Geol. Surv., Publication No.253, p.5

spread distribution of a fine-grained, ferruginous sandstone. This rock is very characteristic, and is developed on one or perhaps more horizons. It has been observed from the following localities: Beaudesert, Kalbar (late Engelsburg), near Warwick, near Toowoomba, three miles north of Texas, a number of localities in the Wallumbilla-Roma district, and Stewart's Creek, Rockhampton. All these occurrences are in the Walloon Series or its equivalents. This rock, in nearly every case, contains fossil plants, the genus *Otozamites* being particularly characteristic. It is also to be noted that, in the Jurassic rocks of Western Australia, *Otozamites* occurs in a fine-grained, ferruginous sandstone.

The widespread distribution of this rock, apparently on a few horizons, leads us to believe that it gives indication of some special conditions of deposition. It would, however, be useless to attempt to account adequately for it in the present state of our knowledge of the conditions under which these beds were laid down; most of the areas from which it has been obtained have not yet been studied in detail geologically.

(*d*) *Coals.*—The development of a number of coal-seams of workable quality and thickness is an important feature of the Lower Mesozoic rocks of Queensland. Coal is obtained from both the Ipswich and Walloon Series, and the character of the coal from the two Series is generally distinct. This distinction has been expressed both by Mr. Cameron and Mr. Marks. The former, speaking of the Walloon coals, says* "the coals hitherto found show characteristic conchoidal fracture in the hand-specimen, burn readily with a long, luminous flame, and give off a much larger proportion of volatile hydrocarbons when heated in a closed vessel than do the brittle, bituminous coals of the Ipswich Beds."

On the same subject, Marks says† "The Walloon Beds are characterised by coals which, like those of the Darling Downs, are of the nature of a cannel coal—highly gaseous, hard, and

* Queensland Geol. Surv., Publication No.204, p.16.

† Queensland Geol. Surv., Publication No.225, p.9.

breaking with a conchoidal fracture, in contrast to the more brittle bituminous coal of the Ipswich Beds."

The Ipswich coals are steam-coals, and are suitable for heating and coke-making; the Walloon coals are essentially gas-coals. A table of typical analyses of the coals from various areas has been published by Mr. Dunstan,* from which we may quote the typical Ipswich and Walloon coals for comparison.

	Ipswich Coal.		Walloon Coal.	
	Mean %.	Range.	Mean %.	Range.
Moisture	1·5	2·0–0·7	6·0	8–4
Volatile hydrocarbons ...	27·0	33–21	39·0	40–23
Fixed carbon	58·5	72–50	44·0	48–29
Ash	14·0	21–4	11·0	25–6

The most notable point of contrast between the two is in the relation of volatile hydrocarbons to fixed carbon; in the Ipswich coals, the latter is very much in excess of the former, while, in the Walloon coals, the two are of about the same value. In some cases, Walloon coals show a much higher percentage of fixed carbon than of volatile hydrocarbons, and the analysis is then indistinguishable from that of Ipswich coals; in these cases, however, the field-relations of the strata usually supply the explanation for this irregularity, by the presence of intrusive rocks not far away, and resultant alteration of the coal.

In normal cases, then, there is a more or less marked distinction between the coals of the Ipswich and Walloon Series in Queensland, and this distinction is of some practical value in helping to distinguish between the two Series. The Walloon coals are distinctive, and can frequently be recognised with a reasonable amount of certainty as belonging to that Series. The Ipswich coals, however, though they are distinct from the Walloon coals, are very similar to the coals of the Burrum Series, of Cretaceous age, and their age cannot be identified by the nature of the coal.

* Queensland Geol. Surv., Publication No.239, p.23.

(*e*) *Extent and Distribution.*—(i.) *The Ipswich Series.*—The Ipswich Series is of comparatively limited extent, and has a thickness, in the type-district, of about 2,000 to 2,500 feet, as estimated by Mr. W. E. Cameron. Its best development is in the Ipswich district, where the strata have been studied in detail by Mr. Cameron.*

North-west of the town of Ipswich, the north-western end of the Ipswich Series is hidden by Cainozoic rocks. Mapping in this portion of the area has not been carried out in detail, but apparently the Ipswich Series cuts out between the Bundamba Series and Brisbane Schists (as shown in Plate ii.), and it is not known to outcrop further in this direction. It is, of course, possible that this series extends some distance north under the Walloon Series, but one might expect, in this case, to find some indication of its presence by outcrops between the outcrops of the Walloon Series and the older rocks to the east.

From Ipswich, the Ipswich Series extends in a general easterly direction to Oxley, where it disappears beneath overlying Cainozoic rocks, as shown on the most recent maps prepared by Mr. Cameron. It reappears along a line running approximately N.30°W.-S.30°E through Brisbane, and is succeeded to the east by a line of schists of Palæozoic age. This belt of Palæozoic rock is not very wide here, and, on the eastern side of it, the Ipswich Series reappears. Between Mt. Cotton and Mt. Petrie, the two belts of Ipswich Series are in direct connection, as also are they between Mt. Petrie and White's Hill

Still going to the east, the Ipswich Series again disappears under the overlying Bundamba sandstone along a line running in a N.30°W. direction through Hemmant, and reappears on the other side of a syncline at various points on the coast south of the Brisbane River. The axis of this syncline is in a direction N.30°W.-S.30°E.

The whole of the Ipswich Series so far described skirts the southern extremity of an extensive occurrence of the schists known as the Brisbane Schists, whose age is uncertain, and can only be stated definitely as Pre-Mesozoic.

* Queensland Geol. Surv., Publications Nos. 147, 204.

From the Brisbane River, extending north as far as Maryborough, there is a narrow, coastal belt of Lower Mesozoic rocks. These are, here and there, intruded or overlain by volcanic rocks of Cainozoic age, with which we are not concerned here. The Mesozoic rocks of this coastal belt are gently folded into anticlines and synclines, the general direction of dip being north-easterly or south-westerly.

This coastal belt averages about 15 to 20 miles in width. At its southern end, it consists of rocks of the Ipswich Series, representing a continuation of the syncline just mentioned south of the Brisbane River. The Bundamba sandstone in this synclinal area does not extend much north of the Brisbane River, and appears to be entirely surrounded on its northern end by the Ipswich Series. The north-eastern side of this syncline, produced northwards, forms the south-western arm of an anticline whose axis passes approximately through the region of the Glasshouse Mountains, in a direction N.30°W., and whose north-eastern arm dips away towards the north-east under the sandstones of the Toorbul Point-Landsborough district, which probably represent the Bundamba Series.

This is the last that is seen of the outcrop of the Ipswich Series, and their extent under the Bundamba Series to the east and north east cannot be determined.

The distribution of this Series is indicated generally in Plate ii.

(ii.) *The Bundamba Series.*—The Bundamba Series comprises a development of massive sandstones in which there are practically no fossils, the only ones so far recorded being examples of fossil wood. Mr. Cameron estimates the thickness of the Series at between 3,000 and 5,000 feet.

This Series overlies the Ipswich Series conformably. It extends, roughly, from the Ipswich District eastwards to a little beyond the railway-line between South Brisbane and Kingston, and in a general south-easterly direction past Canungra to the New South Wales border. It is impossible, in this area, to define accurately the limits of the formation, but its existence is beyond doubt. Mr. Dunstan has recently observed it in New South Wales, not far from Mt. Warning.

The Series also occupies a syncline, with an axis in a direction approximately N.30°W.-S.30°E., between Hemmant and Wynnum, extending southwards to about the latitude of Redland Bay, and northwards only just beyond the Brisbane River. Further north, there is a parallel belt of the Bundamba Sandstone extending from Toorbul Point in a direction approximately N.30°W. through the Landsborough district. The presence of the Bundamba sandstones has been indicated at Toorbul Point by Mr. Cameron.* At this point, a bore (the Bribie View Bore) in Portion 28, Parish of Toorbul, passed through 508 feet of massive sandstones, with one or two seams of hard, black, sandy shales and, near the bottom, pebbly conglomerates; no coal-seams were observed in these sandstones. Mr. Cameron correlated these sandstones with the Bundamba grits and conglomerates occurring at Logan Village. The sandstones of the Landsborough district have been correlated with the Bundamba Series by Mr. Dunstan.†

It can thus be recognised, that there is a belt of the Bundamba Series running through this area, and its position can be defined in a general way, but the exact determination of its boundaries would involve a careful geological survey of the whole area, and it is not certain even then that the boundaries could be accurately defined.

This belt disappears towards the north-east under the southern extension of the Tiaro Series, which is equivalent to the Walloon Series. The distribution of the Series is indicated in Plate ii.

The Helidon sandstones may be the equivalents of the Bundamba sandstones, as suggested by Mr. Dunstan,† but we do not know sufficient detail of the geology of the Helidon district, at present, to be sure of their position.

(iii.) *The Walloon Series.*—The rocks belonging to this Series cover a vastly wider area than either the Ipswich or Bundamba Series. Their distribution is indicated in Plates i. and ii. In South-eastern Queensland, they outcrop over most of the country between a line drawn from just west of Esk to Toowoomba, thence along the eastern foot of the Main Range to the New

* Ann. Rept. Dept. Mines, Queensland, 1908, p.172.

† Queensland Geol. Surv., Publication No 252, p.4.

South Wales border, and a line drawn roughly from Ipswich to Canungra, and thence to the New South Wales border. In a good deal of this area, they are overlain by volcanic rocks of Cainozoic age, but there is no doubt that they are practically continuous through the whole area. In addition, there is a belt, five to fifteen miles wide, from Esk up the valley of the Brisbane River nearly to Cooyar Creek, but this belt is not a continuous outcrop; there is also an extension from Esk in a north-easterly direction past Mt. Brisbane.

Rocks belonging to the Walloon Series also outcrop very extensively to the west of the Main Divide. There is probably a continuous belt from the New South Wales border near Killarney, running through Warwick to Dalby and Chinchilla, then swinging round to an east and west direction parallel to the railway-line past Roma. The exact extent of the belt past this point is not absolutely proven, but there seems little doubt that it swings round in a general north-north-westerly direction, and extends right to the Gulf of Carpentaria towards Cape York. Mr. Dunstan* has placed, in the Walloon Series, sandstones and shales in this belt at the following localities: the Upper Maranoa River, the Upper Dawson River, Jericho, the Upper Flinders River, Croydon, and probably the heads of the rivers flowing westerly across the Cape York peninsula to the Gulf of Carpentaria.

This belt dips to the west and south-west, and underlies, with apparent conformity, the marine Cretaceous rocks of the Rolling Downs Series. In the east, the Walloon Series is represented by a number of occurrences scattered over a very wide area. To the south and south-west of Maryborough is the Tiaro Series (equivalent to the Walloon Series); other occurrences include those at Callide Creek, Westwood-Wycarbah-Stanwell district, Waterpark, Brovinia, a small area about 10-15 miles west of Mundubbera, a small area west of the Burnett River in latitude 25° 45′S., a small area west of Barambah Creek in latitude 26°S., at Mondure on Barambah Creek, and the Laura Coalfield, Cooktown district. The exact positions of these areas are shown on

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* Harrap's Geography of Queensland, 1916, p.166.

Plates 3, 5, and 9 of the Queensland Mineral Index. On Plate 11 of the same work, a small patch is shown as belonging to the Walloon Series, just west of Anakie. Mr. Dunstan, who investigated the Anakie district some years ago, kindly informed me that there is no representative of the Walloon Series in that district, and that the colouring of this area as Walloon was due to an error in lithographing. Another area, to which attention should be called, is that of the Styx River, marked on Plate 3 of the Mineral Index as belonging to the Ipswich Series. Mr. Dunstan now believes this to be of Cretaceous age, and has recently obtained, from the Styx River Coal-Measures, a fragment which appears to be a dicotyledonous leaf. This is an interesting find, and the greatest age, which can reasonably be assigned to these Measures in view of it, is Cretaceous.

In the case of most of the isolated occurrences of the Walloon Series just mentioned, there is sufficient evidence to render it almost certain that the determination of the age is correct. The evidence is here summarised :—

In the Westwood-Wycarbah-Stanwell district, the fossil flora is distinctly of the Walloon type (*infra*, Table vii.). At Waterpark, the coal is of Walloon type, but there appears to be no record of fossils. The areas in the vicinities of Brovinia, Mundubbera, Burnett River, Barambah Creek, and Mondure are all residuals, occupying rather higher ground, and Mr. Dunstan is of opinion that they undoubtedly represent outliers of the extensive outcrop a little to the south-west. In the Laura coalfield, the strata consist of arenaceous beds, with occasional thin beds of shale and coal-seams. Mr. Ball records the finding of the following fossils: *Phyllotheca*(?), *Tæniopteris*, *Alethopteris*, *Brachyphyllum*, and *Taxites*(?). The presence of *Brachyphyllum* and *Taxites*(?) is sufficient to indicate a Walloon age. In the remaining area, Callide Creek, there is no definite indication of age; the fossils, *Thinnfeldia odontopteroides* [= *T. Feistmanteli*], and *Tæniopteris* sp., have been recorded, but they are not sufficient to determine the age. In view, however, of the wide distribution of strata of Walloon age, the Callide Creek beds are regarded as probably of similar age.

It is thus seen that the Walloon Series extends uninterruptedly over a great part of Eastern Queensland. Though occurring in comparatively small, isolated areas at the present time, I believe that these occurrences represent the remnants of a deposition which probably covered the greater part of Queensland. This will be discussed later.

Further, that the western belt, extending past Toowoomba and Warwick, probably extends a great deal further west than is shown on the map, is indicated by the known occurrences of Lower Mesozoic rocks to the south-west of Dalby, and west of Warwick.

Towards the south, this belt divides into two; the eastern portion extends past Killarney into New South Wales, and is continuous with the western extent of the Clarence Series; and the western portion continues along the western margin of New England, and dips away to the west under the marine Cretaceous. In New South Wales, this latter belt is known as the Artesian Series.

It must be noted that the Walloon Series, in the Toowoomba-Warwick District and in South-eastern Queensland, have probably been separated by heavy faulting along the Main Range, but were formerly continuous; and it is quite natural, therefore, that this Series should, in these two areas, be continuous with parts of the Clarence Series of New South Wales.

That the Walloon Series continues for great distances westward under the Cretaceous rocks, is proved by the Artesian bores of Queensland and New South Wales. It is fairly well established now that the rocks from which the Artesian water (or rather that part of it which is of meteoric origin) is obtained, are part of the so-called Trias-Jura System, and not of the Cretaceous System. This fact is of great value in determining the extent to which the Lower Mesozoic rocks continue under the Cretaceous.

Small flows of water have undoubtedly been obtained from the Cretaceous rocks, but the rocks from which the large flows of water have been obtained are of Lower Mesozoic age. Examination of the bore-records, then, will show the extent of the

Lower Mesozoic rocks, both in Western Queensland and in New South Wales. At some places, there is a very great thickness of Cretaceous and possibly Cainozoic strata overlying the Lower Mesozoic rocks; *e.g.*, in South Australia, the bore at Goyder's Lagoon struck water-bearing strata at 4,700 feet, and the Patchawarra bore was abandoned at a depth of 5,458 feet, being still in the Cretaceous rocks.

Palæontological proof of the age of the water-bearing strata in the bores is not often forthcoming, but, in a number of cases in New South Wales, records have been made, *e.g.*, (*a*) in the Bulyeroi bore, 60 miles W. by S. of Moree, Lower Cretaceous rocks with marine fossils were passed through down to 520 feet, and then shales, sandstones, and coal-seams with fossil plants; (*b*) in the Wallon bore, 20 miles N. by W. of Moree, Lower Cretaceous rocks with marine fossils were encountered down to 1,500 feet; at 1,630 feet, fragments of *Tæniopteris spatulata* [*T. Daintreei*] were obtained, and water was struck at 2,330 feet; (*c*) in the Coonamble bore, both *Tæniopteris spatulata* [*T. Daintreei*], and *Thinnfeldia odontopteroides* were obtained. These are not all of the recorded occurrences.

The Walloon Series (or its equivalents) is considerably thicker than the Ipswich or Bundamba Series. In Western Queensland (Roma District), the map and sections prepared by Messrs. Saint-Smith and Thom show a width of outcrop of about 60 miles, and dips of the order of 3 or 4 degrees; the dips are small, but, if the average dip be only 2 degrees, the thickness represented is about 11,000 feet. In the Maryborough District, the thickness of the Tiaro Series has been estimated at 12,000 feet by Messrs. Blake and Bryan.

(*f*) *Artesian Water.*—A general consideration of the Lower Mesozoic rocks of Queensland would not be complete without some reference to the question of artesian water. This question has been the subject of considerable controversy between the exponents of the two theories as to the origin of the water, known respectively as the "Meteoric" Theory, and the "Plutonic" Theory. Suffice it to state, that there seems now to be no reasonable doubt that a large portion of the water is of meteoric origin, and that the belt of Lower Mesozoic rocks extending, probably without interruption, from near Dubbo in New South Wales, to the Cape York Peninsula, forms the intake-beds of the Great Australian Artesian Basin. Probably also a small percentage of the water is of plutonic origin. It is also now generally agreed among Australian geologists that, in the Great Australian Artesian Basin, the rocks, from which all the large flows of water are obtained, are of Lower Mesozoic age, underlying the Marine Cretaceous (Rolling Downs) Series.

An examination of the bore-records shows conclusively that the sandstones of the Walloon Series in Queensland, and the Artesian Series in New South Wales, extend continuously in a westerly and south-westerly direction into the north-eastern portion of South Australia. The depths at which the sandstone is found vary, but, in general, the deepest occurrences are in the north-eastern corner of South Australia, not far from the Queensland border.

It must be noted here, that, near the border between Queensland and New South Wales, in the vicinity of Hungerford, there are patches of granite at the surface, and also that some of the bores in that vicinity have struck granite at comparatively shallow depths. There is here, then, indication of an island in Lower Mesozoic time.

In the north-east of South Australia, where the Lower Mesozoic sandstones are at great depths, it seems probable that the strata above them include Cainozoic, Cretaceous freshwater-beds (equivalent to the Winton Series of Western Queensland), and Cretaceous marine beds (Rolling Downs Series). This is inferred from a comparison with conditions in parts of Queensland; in the great majority of bores, unfortunately, the records kept are of little value for detailed geological purposes. In the case of the Patchawarra bore in South Australia, which was abandoned at 5,458 feet without reaching the water-bearing strata, it appears that the bore, when abandoned, was still in the Cretaceous rocks, and there is nothing to indicate that the Artesian Series of sandstones does not exist further down. I am indebted to Mr. L. Keith Ward, Government Geologist of South

Australia, for supplying me with all available information regarding this bore. Mr. Ward also remarks that the bores sunk by the South Australian Government, with the exceptions of Hergott and Marree at the margin of the basin, have failed to reach bedrock. In other bores in the north-east of South Australia, water is obtained from sandstones at great depths, indicating surely the presence of equivalents of the Walloon Series, *e.g.*, Goyder's Lagoon Bore, 4,700 feet; Mount Gason Bore, 4,420 feet; and others.

Examples of palæontological proof of the age of the sandstones, carrying the large supplies of artesian water, are quoted above (*see* p.58), and these show that the presence of artesian water is an indication of the existence of the Lower Mesozoic Sandstones, and can be used in the determination of the extent of these beds.

(*g*) *Folding-movements* In studying the folding-movements to which the Lower Mesozoic rocks of Queensland have been subject, two areas may be considered separately, viz., (*a*) the western belt, extending from the Cape York Peninsula to the New South Wales border, and (*b*) the occurrence in South-eastern Queensland. (*a*) The western belt has not been subject to any considerable movement, and the rocks usually dip gently to the west and south-west beneath the marine Cretaceous strata; occasional high angles of dip have been observed. (*b*) In South-eastern Queensland, a study of the distribution and directions of dip shows that the Lower Mesozoic rocks have been considerably folded, and that the folding in some cases gives place to faulting. The folding takes the form of a series of anticlines and synclines, whose axes are in a direction approximately N.30° W.-S.30°E. The distribution of the Lower Mesozoic strata in South-eastern Queensland has never been thoroughly understood, but the recognition of this series of folds seems to explain the distribution in a simple and reasonable manner. In places, the folding gives place to faulting, *e.g.*, north of Ipswich, and probably also near Hemmant. Mr. Ball has also described a fault near Woodford,* which he believes to represent a continuation

* Queensland Government Mining Journal, xvii., 1916, p.169.

of the supposed fault at Hemmant. The general directions of the dip and of the axes of folding are shown in Plate ii.

The extent of this folding, which has affected both the Lower Mesozoic rocks and the overlying Cretaceous strata, has not been generally recognised, as may be seen from the following quotations. Dr. Jensen* says, "Our Mesozoic sediments show no folding of consequence. Generally speaking, they show only slight dips, and have never been under the influence of tangential pressure like the Mesozoic sediments of the Alps, Himalayas, Java, etc." Dr. Richards,† writing of South-eastern Queensland, says, "Folding-movements of only a very gentle nature have taken place since the Palæozoic era."

Such statements are not consistent with the folding which has been observed to the west of Ipswich, in the neighbourhood of Hemmant; and in the Maryborough District, particularly on Woody Island, where the strata are often nearly vertical.

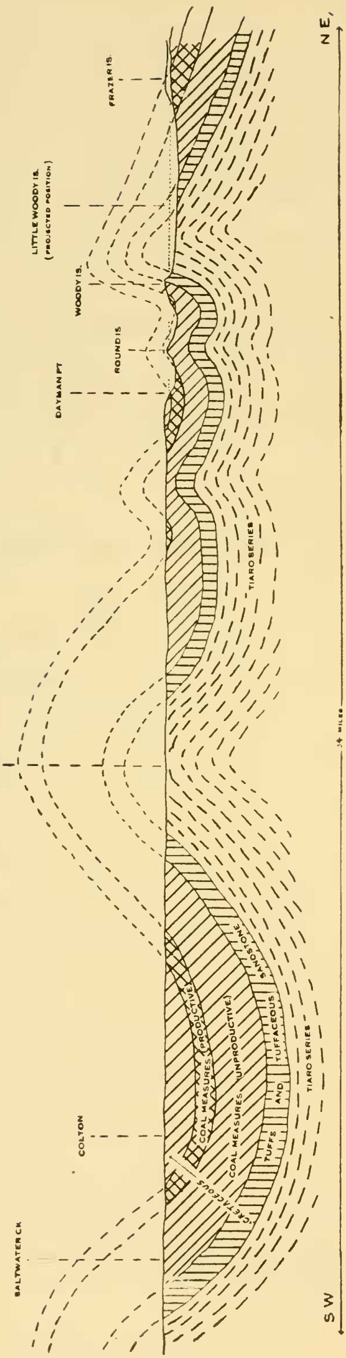
The nature of the folding is illustrated in two Sections (Text-fig. 1), of which Section A has been prepared from a section drawn by Mr. Dunstan, and Section B from a combination of sections by Messrs. Cameron and Marks. Neither Mr. Dunstan's nor Mr. Cameron's original section has been published, and I am indebted to them for permission to modify these sections for use here.

This folding may be quite adequately and reasonably explained as the result of the adaptation of the earth's crust to a shrinking nucleus. Such folding would, naturally, be expected along zones of weakness, and the east coastal area of Australia is undoubtedly such a zone. Folding of this nature often passes into faulting, and this may have occurred near Hemmant, where there seems to be a line of faulting associated with folding, and also in the Ipswich District, where, Mr. Cameron informs me, the severe folding just south of Ipswich gives place to a fault further north.

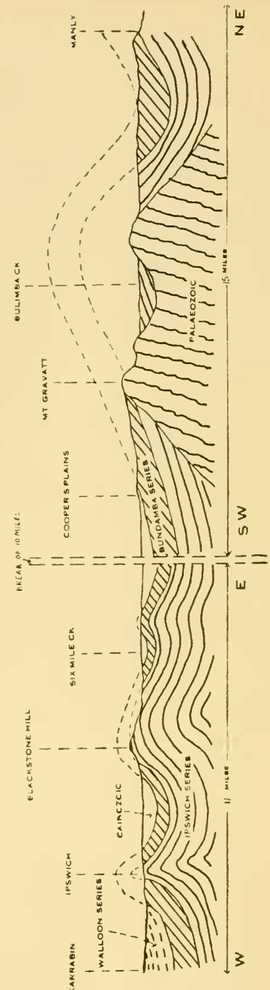
From the originals of the sections, it was possible to estimate, approximately, the amount of shortening of the earth's crust

* Proc. Roy. Soc. Queensland, xxiii., Pt.2, p.163.

† Proc. Roy. Soc. Queensland, xxvii., Pt.2, p.114.



Text-fig. 1A.



Text-fig. 1B.

Text-fig. 1A.—Sketch-Section from near Colton to Frazer Island, showing the folding of the Jurassic and Cretaceous rocks. Vertical scale exaggerated about $2\frac{1}{2}$ times. (Modified from Section drawn by Mr. B. Dunstan).

Text-fig. 1 B.—Diagrammatic Section from Ipswich to Manly, showing the folding of the Lower Mesozoic Strata. Vertical scale exaggerated. (Modified from Sections by Messrs. W. E. Cameron, B.A., and E. O. Marks, B.A.).

represented by the folding. Both sections are approximately at right angles to the axes of folding. In the section between Ipswich and the mouth of the Brisbane River, a shortening of the order of $1\frac{1}{8}$ miles in 34 miles has been effected; and, in the Maryborough district, a shortening of about 0·8 mile in 34 miles. This shortening is circumferential, and if it be regarded as the shortening represented at this particular time for the east-west extent of Australia (a not unreasonable supposition, since we know of no other folding of the same age across Australia), the radial shrinkage represented would be of the order of 0·05%.

Regarding the age of the folding, it certainly took place after the Burrum Coal-Measures (probably Lower Cretaceous) were deposited, for both Marine Cretaceous strata, which are apparently conformable with the Tiaro Series, and the overlying Burrum Coal-Measures have been subject to this folding force, and have been folded to an extent closely comparable with the Lower Mesozoic strata. This is shown by a comparison of Sections A and B.

This same folding took place before the Cainozoic, since it has not affected any of the Cainozoic rocks of South eastern Queensland. Also the disposition of the Cainozoic volcanic rocks in South-eastern Queensland indicates that the Pre-Cainozoic drainage-system was approximately meridional, and this may be closely connected with the N.30°W. strike of the folds of the Lower Mesozoic rocks.

In the Ipswich District, there appears to have been a subsequent period of folding. This is comparatively restricted, and the folds produced by it have an approximately meridional direction. The Cainozoic deposits have been affected by this movement, which must, therefore, have been later than the period of folding already mentioned. I am indebted to Mr. Cameron for information regarding this latter folding.

Flora of the Lower Mesozoic Rocks of Queensland.

The lists, presented below, of the floras of the Ipswich and Walloon Series have been prepared after a careful examination of the specimens available in the collections of the Queensland Geological Survey, the University of Queensland, the Queensland Museum, and the "Simmonds" Collection. In addition, previous records have been examined and verified as far as possible, and, only when it is believed that they are reliable, have they been included. In cases where the original specimens have been lost, the records have been used only when the determination is not subject to the least doubt. These lists, then, are regarded by the author as being as complete and reliable as it is possible to make them, in the light of our present knowledge.

(*a*) *Ipswich Series.*—The flora of the Ipswich Series comprises the following species :—

EQUISETALES.

Equisetites rotiferum Tenison-Woods.
Equisetites sp. (tubers).
Phyllotheca australis Brongniart.
Neocalamites hœrensis (Schimper).
Neocalamites cf. *Carrerei* Zeiller.
Schizoneura cf. *africana* Feistmantel.

FILICALES.

Osmundaceæ.
Cladophlebis australis (Morris).
C. Roylei Arber.
Cyatheaceæ.
Coniopteris delicatula (Shirley).
Dipteridinæ.
Dictyophyllum rugosum Lindley and Hutton.
Thinnfeldieæ.
Thinnfeldia Feistmanteli Johnston.
Th. lancifolia (Morris).
Th. odontopteroides (Morris).
Th. acuta Walkom.
Marattiaceæ.
Danæopsis Hughesi Feistmantel.
Hydropterideæ(?).
Sagenopteris rhoifolia (Presl).

GENERA OF FERNS AND PLANTÆ INCERTÆ SEDIS.

Sphenopteris lacunosa Shirley.

Sph. superba Shirley.

Tæniopteris Tenison-Woodsi Etheridge Jr.

T. Carruthersi Tenison-Woods

T. lentriculiforme (Etheridge Jr.).

T. Dunstani Walkom.

T. wianamattæ (Feistmantel).

T. crassinervis (Feistmantel).

Stenopteris elongata (Carruthers).

GINKGOALES.

Ginkgo antarctica Saporta.

G. digitata (Brongniart).

G. cf. *magnifolia* Fontaine.

Baiera Simmondsi Shirley.

B. bidens (Tenison-Woods).

B ipsviciensis Shirley.

B. ginkgoides Shirley.

(?)GINKGOALES.

Stachyopitys annularioides Shirley.

S. Simmondsi Shirley.

CYCADOPHYTA.

Bennettitales.

Bennettites (*Williamsonia*) sp.

CYCADOPHYTA INCERTÆ SEDIS.

Pterophyllum multilineatum Shirley.

Gymnospermous seeds.

Examination of this list at once shows certain distinctive features, the most notable being the comparatively large number of Ginkgoales, the relatively few Cycadophyta, and apparent entire absence of coniferous remains.* The small proportion of

* This statement may need subsequent modification. Silicified woods from the Ipswich Series have, in the past, been described as *Araucarioxylon* spp. These woods are at present being re-examined by Professor A. C. Seward, and it is quite possible that they may not be of undoubted coniferous affinities. At any rate, we know of no remains from the Ipswich Series, other than these woods, which may, at the present time, be referred to the Conifers.

Cycads may ultimately be very greatly increased, if it should be shown that the genus *Tæniopteris* belongs to this group. In a recent publication, Thomas includes species of *Tæniopteris* with the Cycadophyta, as a result of his examination of the epidermis of a number of recent and fossil Cycads.* None of the Queensland Lower Mesozoic examples of *Tæniopteris* obtained have been preserved as carbonaceous films, and it is at present impossible to state the nature of the structure of the epidermis in them.

The list of species in this Series may be summarised, and the figures expressed in percentages, as in the following Table:—

TABLE i.

	1 No. of Species.	2 %	3 %	4 %
Equisetales	5	15	15	15
Filicales	10	30		39 (Filicales and Filicales incertæ sedis)
Filicales incertæ sedis ...	3	9	57 (Filicales, Filicales incertæ sedis and Tæniopteris)	
Tæniopteris	6	18		24 (Tæniopteris and Cycadophyta)
Cycadophyta	2	6	6	
Ginkgoales	7	21	21	21
Total	33			

Such tables as these must be used with a good deal of caution, as their indiscriminate use may lead to quite incorrect and even absurd results; but careful use, with a full realisation of their value and their drawbacks, may yield interesting and, to some extent, reliable results. The use of such numerical methods has not come into very general use, but their preparation and use have been illustrated recently by Wieland.†

In the above Table (Table i.) of the Ipswich flora, the species of *Stachyopitys*, and gymnospermous seeds have not been used, since they, in all probability, represent seeds or reproductive organs of plants already represented in the list by sterile fronds. The species of *Tæniopteris* are placed separately in the Table,

* Thomas, Q.J.G.S., lxix.; p.223.

† Amer. Journ. Sci., xxxvi. (1913), pp.268-273.

since their position is uncertain. In column 3, the percentages are given, including *Tæniopteris* with the ferns; in column 4, this genus is included with the cycads. This latter result gives the flora a not abnormal character in the proportion of ferns and cycads, and indicates a general similarity to some Rhætic floras; there are, however, certain points which may indicate a somewhat greater age, *e.g.*, the high percentage of Equisetales, and the rather smaller percentage of Cycads, than is usual in Rhætic and Jurassic floras.

For convenience of reference and comparison, the following Table is quoted from Wieland :—*

Table ii. (after Wieland).
Elements of typical Rhætic-Oolitic Floræ.

	Graham Land, Mid-Jura.	Oroville, Oolite.	Yorkshire, Inferior Oolite.	Bornholm, Lias.	Rajmahal Hills, Lias.	Oaxaca, Lias to Rhætic.	Tonkin, Rhætic.
Ferns	42	46	37	35	32	18	48
Cycadeans	28	38	43	33 +	34 +	70	33
Conifers	27	12	} 16	17	8	(2)	9
Ginkgos	—	4		9	?	—	2
Cordaites	—	—	?	?	?	8	2
Equisetums	2	?	4	5	2	2	5·5

The flora of the Ipswich Series may now be examined in greater detail.

Equisetales.—The percentage of Equisetales in the Ipswich flora is unusually high for a Mesozoic flora. As I have already pointed out,† they show affinities with the Equisetales of Rhætic floras. *Neocalamites hœrensis* occurs in the Rhætic of Sweden, and *Neocalamites Carrerei* in the Rhætic of Tonkin, and in the Stormberg flora (Molteno Beds) of South Africa. *Phyllotheca australis* is one of the few species which continue from the Palæozoic into the Mesozoic in Australia, occurring in the Permian (Permo-Carboniferous) of Eastern Australia, and also in

* Amer. Journ. Sci., xxxvi. (1913), p.272.

† Queensland Geol. Surv., Publication No.252, p.38.

the Wianamatta Stage of the Hawkesbury Series of New South Wales. *Schizoneura africana* occurs in the Beaufort Series in South Africa (Permian), and, according to Seward, is related to *S. gondwanensis* from the Talchir, Damuda, and Panchet Series (Permian and Lower Triassic) of India. The remaining species, *Equisetites rotiferum*, is a widespread type, and very similar forms are widely distributed in both Rhætic and Jurassic strata.

Filicales.— A majority of the true ferns of the Ipswich Series indicate a Rhætic or possibly greater age for the flora. Sterile *Cladophlebis*-fronds of the *C. australis* type are of very widespread occurrence in rocks varying in age from Rhætic to Middle Jurassic. *Cladophlebis Roylei* is a somewhat older type, occurring in the Raniganj Series (Upper Permian) of India. *Dictyophyllum rugosum* is a fairly widespread Jurassic (Lower Oolite) species, but there is so little difference between it and species of *Dictyophyllum* in Rhætic floras, that it cannot be regarded as a reliable indicator of age. The species of *Thinnfeldia* in the Australian Lower Mesozoic rocks do not appear to be represented in the Northern Hemisphere. The three species, *T. Feistmanteli*, *T. odontopteroides*, and *T. lancifolia*, are present in the Molteno Beds in South Africa; and *T. odontopteroides* and *T. lancifolia* in the Mesozoic flora in Argentina. *Danaeopsis Hughesi* is a Rhætic or older form, occurring in the Rhætic Beds of Tonkin, the Burghersdorp Beds of South Africa (Triassic), and the Middle Gondwanas of India (Triassic). *Sagenopteris rhoifolia* is itself a Rhætic species, but it is at times difficult to distinguish between it and *S. Phillipsi*, a common Jurassic form.

Ginkgoales.—The Ginkgoales are represented by a comparatively large number of species, and, in addition, they are also relatively abundant as regards numbers of individuals. *Ginkgo antarctica* occurs in the Lower Mesozoic rocks in New South Wales, but there is no record of its exact locality or horizon. *G. digitata* is a very variable form met with in both Rhætic and Jurassic rocks. *G. magnifolia* occurs in the Jurassic strata of Oregon, and also bears some slight resemblance to *Baiera stormbergensis* from the Stormberg flora of South Africa. *Baiera bidens* is a very common type, and is similar to species which are abundant in both Rhætic and Jurassic rocks. *B. ipsviciensis* may be compared with *B. multifida*, occurring in the Rhætic of North America; and *B. Simmondsi* also occurs in the Wianamatta Stage of the Hawkesbury Series of New South Wales. *Stachyopitys annularioides* is a very similar type to specimens referred to as *Stachyopitys* sp., in the Stormberg flora of South Africa, and also to *Sphenolepis rhætica* from the Rhætic of San Juan (Argentine).

Cycadophyta.—The percentage of species of this group is unusually small in the Ipswich Series. Should the genus *Tæniopteris* ultimately prove to be a cycad, however, the percentage of cycads in the Ipswich flora would be a normal one for early Mesozoic floras. The specimen showing expanded bracts, referred to *Bennettites* (*Williamsonia*) sp., cannot be regarded as indicating any special age, as it agrees with similar specimens from the Mixteca-Alta flora of Mexico (Rhætic-Liassic), and also with *B. Carruthersi* from the Wealden of England. *Pterophyllum multilineatum* occurs in the Rhætic of Tonkin, and similar species are found in the Burghersdorp Beds of South Africa.

Genera incertæ sedis.—The species of *Sphenopteris* do not offer any evidence as to the age of the Series. Species of *Tæniopteris* are not usually to be regarded as reliable indicators of geological age. Of the species in the Ipswich Series, some appear to be confined to Australia, while others of them occur in South Africa and India. *T. Tenison-Woodsi* and *T. Carruthersi* are found in the Stormberg flora (Molteno Beds), and the latter also in the Burghersdorp Beds in South Africa; *T. crassinervis* occurs in the Rajmahal Series (Lias) of India. *Stenopteris elongata* occurs also in the Stormberg flora of South Africa.

The accompanying Table (Table iii.) shows the relationships of the species of the Ipswich flora to species in other floras. The Table is arranged in four columns, column 1 showing the species with affinity to species older than Rhætic, column 3 those with affinity to species in Rhætic floras, and column 4 those of Jurassic affinity. The Stormberg flora of South Africa is so similar in general appearance, that the species common to the two are grouped separately in column 2.

TABLE iii.

The flora of the Ipswich Series, arranged to show the relation of the species to those of other floras.

1	2	3	4
Species with affinity to species occurring in beds older than Rhætic.	Species identical with, or closely allied to, species occurring in the Stormberg flora (South Africa)	Species identical with, or closely allied to, species occurring in strata regarded as Rhætic.	Species with affinity to species in Jurassic floras.
Phyllotheca australis (Permo-Carb.) *Schizoneura* cf. *africana* (Permian) *Cladophlebis Roylei* (Upper Permian, India) *Danæopsis Hughesi* (Burghersdorp Beds, S. Africa; Middle Gondwana, India) *Tæniopteris Carruthersi* (Burghersdorp Beds) *Pterophyllum multilineatum* (Burghersdorp Beds)	*Neocalamites Carrerei* *Thinnfeldia Feistmanteli* *T. lancifolia* *T. odontopteroides* *Tæniopteris Carruthersi* *T. Tenison-Woodsi* *Stenopteris elongata* *Ginkgo magnifolia* (=?*B. stormbergensis*) *Stachyopitys annularioides* (*S.* sp.)	*Equisetites rotiferum* *Neocalamites hœrensis* (Sweden) *N. Carrerei* (Tonkin) *Cladophlebis australis* *Danæopsis Hughesi* (Tonkin) *Sagenopteris rhoifolia* *Ginkgo digitata* *Baiera bidens* *B. ipsviciensis* (*B. multifida*, North America) *Pterophyllum multilineatum* (Tonkin)	*Equisetites rotiferum* (*E. columnaris*, M. Jur.) *Cladophlebis australis* *Dictyophyllum rugosum* *Tæniopteris crassinervis* (Rajmahal, Lias) *Ginkgo digitata* *G. magnifolia* *Baiera bidens*

This Table at once shows that the flora of the Ipswich Series is of a facies at least as old as Rhætic. In addition to the species occurring in Rhætic floras, there are also a number of species which occur in other parts of the world in rocks older than Rhætic. The number of species in the Ipswich flora, which represent Jurassic types, is not large, and nearly all of these are examples of species in which it is often difficult to find satisfactory distinctions between Rhætic and Jurassic species. The only two species of the Ipswich flora, which are characteristic of Jurassic rocks, are *Tæniopteris crassinervis* and *Ginkgo magnifolia*; and, regarding the latter of these, I have a slight doubt as to the determination in the Ipswich Series

Of twenty-two species in this Table, eighteen occur in Rhætic floras, six occur in floras older than Rhætic, and seven in Jurassic floras, only two of the latter, however, being characteristic of Jurassic floras.

The Table, together with the foregoing discussion, shows fairly conclusively that the flora of the Ipswich Series must be regarded as at least as old as Rhætic, and probably somewhat older.

(*b*) *Walloon Series.*—The flora of the Walloon Series comprises the following species :—

EQUISETALES.

Equisetites rotiferum Tenison-Woods.
Equisetites cf. *rajmahalensis* Oldham and Morris.
Schizoneura sp.*a* Seward.
Schizoneura sp.

FILICALES.

(?)Osmundaceæ.
Cladophlebis australis (Morris).
C. Roylei Arber.
(?)Matonineæ.
Phlebopteris alethopteroides Etheridge Jr.
Dipteridinæ.
Dictyophyllum rugosum(?) Lindley and Hutton.
D. Davidi Walkom.
Hausmannia(?) *Buchii* (Andræ).

Thinnfeldieæ.

Thinnfeldia Feistmanteli Johnston.

Th. odontopteroides (Morris).

Th. lancifolia (Morris).

(?)Hydropterideæ.

Sagenopteris rhoifolia (Presl).

GENERA INCERTÆ SEDIS.

Sphenopteris superba Shirley.

Stenopteris elongata (Carruthers).

Phyllopteris Feistmanteli Etheridge Jr.

Tæniopteris spatulata McClelland.

T. spatulata var. *major* Seward.

T. Tenison-Woodsi Etheridge Jr.

T. Carruthersi Tenison-Woods.

T. lentriculiforme (Etheridge Jr.).

T. crassinervis (Feistmantel).

GINKGOALES.

Ginkgo magnifolia Fontaine.

Baiera Simmondsi Shirley.

CYCADOPHYTA.

Bennettitales.

Ptilophyllum (*Williamsonia*) *pecten* (Phillips).

CYCADOPHYTA INCERTÆ SEDIS.

Pterophyllum abnorme Etheridge Jr.

P. contiguum Schenk.

P. Nathorsti (Seward).

Pseudoctenis eathiensis (Richards).

Otozamites queenslandi Walkom.

O. obtusus (Lindley and Hutton).

O. Feistmanteli Zigno.

O. Mandelslohi Kurr.

CONIFERALES.

Araucarites polycarpa (Tenison-Woods)

Brachyphyllum crassum Tenison-Woods

Taxites planus Feistmantel.

GENUS INCERTÆ SEDIS.

Phœnicopsis elongatus(?) (Morris).

The outstanding feature of this flora is the large increase in the number of cycads. Other noticeable points are the decided decrease in the number of species of Ginkgoales, and the presence of a few Conifers.

Arranged in tabular form, and omitting from the Table *Schizoneura* sp., which may possibly be the external casts of which *S.* sp. *a* is the pith-cast, and also *Phœnicopsis elongatus*, whose position is quite unknown, the following result is obtained.

Table iv.

——	1 No. of species.	2 %	3 %	4 %
Equisetales	3	8	8	8
Filicales	10	28		36 (Filicales + Filicales incertæ sedis)
Filicales incertæ sedis ...	3	8	53 (Filicales + Filicales incertæ sedis + Tæniopteris)	
Tæniopteris	6	17		42 (Tæniopteris + Cycadophyta)
Cycadophyta	9	25	25	
Ginkgoales	2	6	6	6
Coniferales	3	8	8	8
Total	36			

This Table shows distinct differences from that of the Ipswich flora (Table i., p.66), and when, as in column 4, the species of *Tæniopteris* are combined with the Cycads, the percentages agree quite well with the percentages in Jurassic floras, particularly with the Lower Oolite flora of Yorkshire (*see* Table ii., p.67).

The flora of the Walloon Series may now be discussed in more detail.

Equisetales.—Members of this group are not of uncommon occurrence in the Walloon Series. *Equisetites rotiferum* is almost indistinguishable from the widely spread *E. columnaris* of Middle Jurassic floras, and *Equisetites* cf. *rajmahalensis* is closely comparable with the species in the Liassic flora of India. *Schizoneura* sp.*a* is identified with the species described from the Stormberg Beds of South Africa. Pith-casts of Equisetales, however, cannot be regarded as of any value in differentiating between Rhætic and Jurassic floras.

Filicales.—The ferns, although not particularly numerous, have the general appearance of a Jurassic flora. *Cladophlebis australis*, as already stated, is a type of frond of widespread occurrence, but is specially close to the *C. denticulata*-type, a widespread Jurassic form. *Phlebopteris alethopteroides* is, in all probability, very closely allied to *Laccopteris polypodioides* from the European Lower Oolite, though there appears to be a difference in the venation. *Dictyophyllum rugosum* is a Jurassic type, but its occurrence in the Walloon Series is doubtful. *Hausmannia Buchii*, with which some specimens from the Walloon Series have been compared, occurs in Jurassic floras of both Liassic and Kimeridgean age. *Sagenopteris rhoifolia*, though itself a Rhætic species, is, at times, indistinguishable from the Jurassic *S. Phillipsi.* The species of *Thinnfeldia*, and *Stenopteris elongata* in the Walloon Series are survivals from the Ipswich flora. The survival of a number of species from the Ipswich flora to the Walloon flora, and even to later floras, in Queensland is to be expected, since there were no violent earth-movements during these times, and no marked changes are known, which might have been expected to lead to any unusual dying out of the older flora. It is indeed fortunate, for stratigraphical study, that there are so many forms in the Ipswich Series, which apparently have not survived into the Walloon Series.

Ginkgoales.—There has been a remarkable change in the number of members of this group. In the Ipswich Series, we have at least seven species represented, while, in the Walloon Series, there are only so far two. *Ginkgo magnifolia* is probably identical with Fontaine's *G. Huttoni* var. *magnifolia* from the Jurassic of Oregon. The other species, *Baiera Simmondsi*, is another survival from the Ipswich Epoch.

Cycadophyta.—Cycads form the most prominent element of the Walloon flora, in which they are present to the extent of at least 25 per cent. of the species, and, perhaps, (if *Tæniopteris* is a Cycad) 42 per cent. On the whole, they indicate very distinctly the aspect of a Jurassic flora. *Ptilophyllum* (*Williamsonia*) *pecten* is a very widespread type in Jurassic (Oolite) floras. Up to the present, there is no indication of any Williamsonia-flowers associated with these sterile fronds of *Ptilophyllum pecten*. *Pterophyllum Nathorsti* occurs in the Jurassic of Sutherland, Scotland, and very similar forms occur in the Jurassic of Oregon ; *Pterophyllum contiguum* occurs in the Jurassic of Oregon, and also in the Rhætic of Tonkin. *Pseudoctenis eathiensis* is practically identical with specimens from the Jurassic of Yorkshire and Sutherland. The three species of *Otozamites*, *O. obtusus*, *O Feistmanteli*, and *O. Mandelslohi* are species occurring widely in Jurassic rocks, and *O. Mandelslohi* occurs in the Mixteca-Alta flora of Mexico.

Coniferales.—Remains of Conifers are not abundant in the Walloon Series. Cones have been described, and referred to the genus *Araucarites*, indicating that they are similar in general to cones of the present-day *Araucaria*. A few fragments have been referred to the genus *Brachyphyllum*, and some specimens to *Taxites*. The specimens referred to *Taxites planus* show a very close resemblance to, and are probably identical with, that species, as described from the Upper Gondwana Beds (Liassic) on the Madras coast of India. Similar forms to *Brachyphyllum crassum* occur in the English Jurassic floras.

The accompanying Table (Table v.) shows the flora of the Walloon Series arranged in two columns, column 1 including those species comparable with species occurring in beds older than Jurassic, and column 2 those comparable with Jurassic species.

TABLE V.

Flora of Walloon Series, showing affinities of species with regard to age.

1 Species with affinity to Species older than Jurassic.	2 Species with affinity to Jurassic Species.
Equisetites rotiferum	*Equisetites rotiferum* (M. Jur.)
Schizoneura sp. *a*	*E.* cf. *rajmahalensis* (Liassic)
Cladophlebis australis	*Cladophlebis australis* (L. Oolite)
C. Roylei	*Phlebopteris alethopteroides* (L. Oolite)
Thinnfeldia Feistmanteli	*Dictyophyllum rugosum* (L. Oolite)
Th. odontopteroides	*Hausmannia* (?) *Buchii* (Liassic; Kimeridge)
Th. lancifolia	*Sagenopteris rhoifolia* (*S. Phillipsi*; Oolite)

Table v.—*(continued)*.

1 Species with affinity to Species older than Jurassic.	2 Species with affinity to Jurassic Species.
Sagenopteris rhoifolia	*Phyllopteris Feistmanteli*
Stenopteris elongata	*Tæniopteris spatulata* (Lias)
Tæniopteris Tenison-Woodsi	*T. spatulata* var. *major*
T. Carruthersi	*T. crassinervis* (Lias)
Ginkgo magnifolia	*Ginkgo magnifolia* (Jurassic of Oregon)
Baiera Simmondsi	*Ptilophyllum* (*Williamsonia*) *pecten* (Oolite)
Pterophyllum contiguum	*Pterophyllum contiguum* (Jurassic of Oregon)
Otozamites Mandelslohi	*P. Nathorsti* (Kimeridge)
	Pseudoctenis eathiensis (Kimeridge)
	Otozamites obtusus (L. Oolite)
	O. Feistmanteli (L. Oolite)
	O. Mandelslohi (Lias)
	Brachyphyllum crassum
	Taxites planus (Lias)

The ages of the species, or of very closely related species, in column 2 are indicated in brackets after each one.

Examining this Table, we find that, excluding the six species common to the two lists, there are nine species with affinities to species older than Jurassic, and fifteen species with Jurassic affinities. Of the nine species regarded as older than Jurassic, eight occur also in the Ipswich Series, and are the species which survived from the Ipswich to the Walloon Epoch; there is only a single species (and that an equisetaceous pith-cast, *Schizoneura* sp.*a*) which could be considered as an argument in favour of an age older than Jurassic for the Walloon Series; whereas there are fifteen species characteristic of Jurassic floras, which appear in the Walloon Series, and were not present in the Ipswich Series. No other conclusion, then, seems possible, than that the flora of the Walloon Series indicates that the Series is homotaxial with strata of Jurassic age, and the greater number of species (*see* Table v.) indicate a lower Jurassic age, Liassic or Lower Oolite. It is possible that the Walloon Series represents deposition over a period covering both the Liassic and Lower Oolite of Europe.

(*c*) *Comparison of floras of the Ipswich and Walloon Series.*—We are now in a position to compare the floras of the Ipswich and Walloon Series. As a result of all previous examinations of these floras, it has been observed that there was no palæontological distinction between the floras of the two Series; *e.g.*, Mr. Cameron states :* "It does not, however, seem possible to draw any distinction between the formations from palæontological evidence, most of the fossils as yet found in the Walloon Beds occurring also in the Ipswich Beds."

The failure to note palæontological distinction between the two has been due, however, to imperfect collecting, and to the fact that the material available has not been thoroughly examined since the examination by Mr. Etheridge, prior to the publication of the "Geology and Palæontology of Queensland and New Guinea," in 1892. In 1898, Dr. Shirley examined and described a number of specimens, but all the Lower Mesozoic specimens among them were from the Ipswich Series. The same author, in 1902 recorded a few more specimens from the Ipswich Series, and some from the Stewart's Creek Beds (of Walloon age). At the time of these publications, however, there was no subdivision of the Ipswich Formation into Ipswich, Bundamba, and Walloon Series, so it is not remarkable that no distinction of horizons was noted in the upper and lower portions of the Formation.

A glance at the following Tables (Tables vi. and vii.) at once shows that there are points in which the two Series can be distinctly separated, and that there are a number of species characteristic of each. These species, characteristic of only one Series, are the more important ones from a stratigraphical point of view, and the finding of some of them may, in the future, be used for fixing the age of the strata in which they occur.

* Queensland Geol. Surv., Publication No.204, p.16.

TABLE vi.

	Ipswich Series. No. of species.	Walloon Series. No. of species.
Equisetales	5	3
Filicales	10	10
Genera incertæ sedis—		
a, probably Filicales ...	3	3
b, Tæniopteris	6	6
Cycadophyta...	2	9
Ginkgoales	7	2
Coniferales	0	3
	—	—
	33	36

TABLE vii.

Table showing distribution in Queensland of the Species of Fossil Plants in the Lower Mesozoic rocks.

	Ipswich Series.	Walloon Series.							
		S.E. Queensland.	Darling Downs.	Roma District.	Upper Brisbane R. (Esk, &c.).	Tiaro Series.	Stanwell-Wycarbah.	Callide Creek.	Laura Coalfield.
Equisetales.									
Equisetites rotiferum ...	×	×		×					(?)
E. cf. *rajmahalensis* ...							×		
Phyllotheca australis ...	×								
Neocalamites hœrensis ...	×								
N. cf. *Carrerei*	×								
Schizoneura cf. *africana* ...	×								
Schizoneura sp.*a*		×			×				
Filicales.									
Cladophlebis australis ...	×	×	×	(?)	×	×	×		(?)
C. Roylei	×	×							
Coniopteris delicatula ...	×								
Phlebopteris alethopteroides ...		×	×						
Dictyophyllum rugosum ...	×			(?)	(?)				
D. Davidi					×				
Hausmannia Buchii(?) ...					×				
Thinnfeldia Feistmanteli ...	×				×			×	
Th. odontopteroides	×				×				
Th. lancifolia	×				×				
Th. acuta	×								
Danæopsis Hughesi	×								
Sagenopteris rhoifolia ...	×		×						
Genera of Ferns and Plants incertæ sedis.									
Sphenopteris lacunosa ..	×								

Table vii.—(*continued*).

	Ipswich Series	Walloon Series.							
		S.E. Queensland	Darling Downs.	Roma District.	Upper Brisbane R. (Esk, &c.).	Tiaro Series.	Stanwell-Wycarbah	Callide Creek.	Laura Coalfield.
Sphenopteris superba	×				(?)				
Stenopteris elongata	×				(?)				
Phyllopteris Feistmanteli ...				(?)			×		
Tæniopteris spatulata ...		×	×	×	×		×		
T. spatulata var. *major* ...		×			(?)		×		
T. Tenison-Woodsi	×				×		×		
T. Carruthersi	×				×		×		
T. lentriculiforme	×			(?)					
T. Dunstani	×								
T. wianamattæ	×								
T. crassinervis	×						×	×	
Ginkgoales.									
Ginkgo antarctica	×								
G. digitata	×								
G. cf. *magnifolia*	×				×				
Baiera Simmondsi	×				×				
B. bidens	×								
B. ipsviciensis	×								
B. ginkgoides	×								
(?)Ginkgoales.									
Stachyopitys annularioides ...	×								
S. Simmondsi	×								
Cycadophyta.									
Bennettites (*Williamsonia*) sp.	×								
Ptilophyllum (*Williamsonia*) *pecten*							×		
Pterophyllum abnorme ...					×				
Pt. contiguum					×				
Pt. multilineatum	×								
Pt. Nathorsti					×				
Pseudoctenis eathiensis ...					×				
Otozamites queenslandi ...					×				
O. obtusus		×							
O. Feistmanteli		×	×						
O. cf. *Mandelslohi*			×						
Coniferales.									
Araucarites polycarpa ...							×		
Brachyphyllum crassum ...		×	×	(?)					(?)
Taxites planus					×		×		(?)
Genus incertæ sedis.									
Phœnicopsis elongatus ...					×				
Gymnospermous seeds ...	×								

The marked difference between the two floras shows in the Gymnosperms. In the Equisetales and Filicales, there is little difference as regards number of species. Only two of the species of Equisetales, and seven of the Filicales, however, are common to the two Series; and, of the others, those in the Ipswich Series are of older type than those in the Walloon Series. When the Gymnosperms are examined, however, a marked distinction between the two Series is to be observed. Twenty-two species are described from the Lower Mesozoic rocks, and only two of these species are common to the Ipswich and Walloon Series. These two species are *Ginkgo* cf. *magnifolia* and *Baiera Simmondsi.* Ginkgoales are abundant, both as regards number of species and number of individuals, in the Ipswich Series, but are only poorly represented in both respects in the Walloon Series. Cycads are represented very sparsely, as regards number of species, in the Ipswich Series, whereas they constitute perhaps the most prominent feature of the Walloon flora, being very widespread in distribution and occurring in large numbers on some horizons. The species of *Otozamites* form one of the most characteristic and distinctive features of the Walloon Series. Up to the present, no Conifers are known from the Ipswich Series,* whilst there are three species representing three genera from the Walloon Series.

Table viii. shows the species occurring in Queensland, which are, so far as we know, found only in one Series of the Lower Mesozoic rocks.

TABLE viii.

Species known only in the Ipswich Series.	Species known only in the Walloon Series.
Phyllotheca australis	*Phlebopteris alethopteroides*
Neocalamites hœrensis	*Dictyophyllum Davidi*
N. cf. *Carrerei*	*Hausmannia*(?) *Buchii*
Schizoneura cf. *africana*	*Phyllopteris Feistmanteli*
Coniopteris delicatula	*Tæniopteris spatulata*
Thinnfeldia acuta	*T. spatulata* var. *major*
Danæopsis Hughesi	*Ptilophyllum* (*Williamsonia*) *pecten*
Sphenopteris lacunosa	*Pterophyllum abnorme*
Tæniopteris Dunstani	*P. contiguum*
T. wianamattæ	*P. Nathorsti*

* See footnote on p.65.

Table viii.—(*continued*)

Species known only in the Ipswich Series.	Species known only in the Walloon Series.
Ginkgo antarctica	*Pseudoctenis eathiensis*
G. digitata	*Otozamites queenslandi*
Baiera bidens	*O. obtusus*
B. ipsviciensis	*O. Feistmanteli*
B. ginkgoides	*O. Mandelslohi*
Stachyopitys annularioides	*Araucarites polycarpa*
S. Simmondsi	*Brachyphyllum crassum*
Bennettites (*Williamsonia*) sp.	*Taxites planus*
Pterophyllum multilineatum	*Phœnicopsis elongatus*
Gymnospermous seeds	

(*d*) *Age of the Queensland Lower Mesozoic Rocks.*—The evidence of the fossil floras of the Ipswich and Walloon Series is very strongly in favour of a Triassic Age for the former, and a Jurassic Age for the latter.

The flora of the Ipswich Series shows marked resemblance to floras which are regarded as Rhætic in age in other parts of the world, particularly those of Tonkin and South Africa. Regarding the actual position in the Geological Record of many of the occurrences classed as Rhætic from their fossil flora, I have received some interesting information from Dr. A. L. du Toit, of the South African Geological Survey.*

Dr. du Toit has come to the conclusion that some of the so-called Rhætic strata would be better placed in the Upper Trias (Keuper) than in the Rhætic. He includes among these the strata in South Africa, Tonkin, and Persia. In the case of South Africa, he finds this is borne out by an analysis of the vertebrate fauna of the Red beds and Cave sandstone overlying the Molteno Beds, which is of Triassic affinities. He concludes that *the flora of the Molteno Beds is of Keuper Age and not younger.*

The Ipswich flora is undoubtedly very similar to that of the Molteno Beds (see Table iii., column 2), but the finding of *Glossopteris* in the latter suggests that it is possibly slightly older than the Ipswich flora.

* Letter dated 2nd December, 1916.

From the evidence available, we are justified in stating that the flora of the Ipswich Series indicates distinctly an Upper Triassic age, possibly Rhætic, but probably older.

The flora of the Walloon Series is decidedly of a Jurassic type, and the typical Jurassic forms in the Series seem to consist of about equal numbers of species characteristic of Liassic and Lower Oolitic strata. The Walloon Series is of very great thickness (probably of the order of 10,000 feet), and when it has been studied in greater detail, it seems quite probable that it may have to be subdivided into a number of stages. For the present, we may regard the Walloon Series as representing a portion of the Lower Jurassic System corresponding at least to the Lias and Lower Oolite.

It is very difficult to draw any reliable conclusion as to whether the Bundamba Series should be placed with the Ipswich Series in the Triassic, or with the Walloon Series in the Jurassic.

There is no fossil evidence which may be taken as a guide. Both Mr. Cameron and Mr. Dunstan have drawn my attention to the usual association of the Bundamba Series with the Ipswich Series, rather than with the Walloon Series; and, on this account, it is, for the present, tentatively placed in the Triassic System with the Ipswich Series.

Correlation of the Lower Mesozoic Rocks of Queensland with those of other areas in Australia.

In considering the correlation of the Queensland Lower Mesozoic rocks with those of the other States, their relations with the States will be discussed separately in the first place, and then the results summarised by drawing up a table indicating the relative positions of the various occurrences.

(*a*) *New South Wales.*—In New South Wales, the strata of Lower Mesozoic age comprise (*a*) the Hawkesbury Series, including the Narrabeen Stage, Hawkesbury Sandstone Stage, and Wianamatta Stage, to which a Triassic age has generally been assigned; (*b*) the Talbragar Beds, the Clarence Series, and the Artesian Series, which have been regarded as of Trias-Jura age.

The Hawkesbury Series is divided into three Stages, viz.:—Narrabeen, Hawkesbury Sandstone, and Wianamatta, in ascending order. The Narrabeen Stage consists mainly of sandstones and shales, the Hawkesbury Stage of massive sandstones characterised by current-bedding, and the Wianamatta Stage mostly of shales.

This Series comprises a basin, and is apparently conformable, in the central portion of the basin, with the underlying Permian (Permo-Carboniferous) System; but, in the marginal areas, there is an overlap amounting to unconformity. The Hawkesbury Sandstone Stage rests conformably on the Narrabeen Stage, while the Wianamatta Stage occupies a slightly eroded basin in the Hawkesbury Sandstone.*

The Talbragar Beds cover only a small area, and occupy a basin eroded in the Hawkesbury Sandstone; and there is no doubt of an unconformity, stratigraphical as well as palæontological, between the Hawkesbury Sandstone and the Talbragar Beds.

The Clarence Series occurs in the north-east of New South Wales, between the New England Tableland and the coast; and, at its northern end, it is continuous with the Walloon Series of Queensland. Reference to the latest Geological Map of New South Wales shows that the Clarence Series is practically continuous with the Walloon Series in the neighbourhood of Mt. Lindsay, and also that, further west, it is continuous with the eastern branch of the belt of Walloon Series on the Darling Downs, extending through Warwick and Killarney to the border of New South Wales.

The Artesian Series of New South Wales exists on the western margin of the New England Tableland, and extends along the eastern margin of the Great Australian Artesian Basin. It is practically continuous into Queensland with the belt of Lower Mesozoic rocks extending past Warwick and Toowoomba. It is seen, then, that the Clarence Series and Artesian Series are each directly connected with the belt of Walloon Series in the Darling

* See Carne, N.S.W. Handbook, B.A.A.S., 1914, pp.601-607.

Downs, and they must, therefore, be identified with one another as regards age, on the evidence of their field-occurrence alone.

Lithologically, the Clarence Series is divisible into three divisions, the middle one consisting of a series of massive sandstones. This lithological division led to a consideration of the possibility of the three stages being the equivalents of the Narrabeen, Hawkesbury Sandstone, and Wianamatta Stages of the Hawkesbury Series. Mr. Carne* has, however, shown, in a convincing manner, that this is not the case.

Another possibility that must be considered is, that the three stages of the Clarence Series might be the equivalents of the Ipswich, Bundamba, and Walloon Series of Queensland. Unfortunately, the Clarence Series has not been examined in great detail geologically, but the fact, that Carne indicates the presence of *Tæniopteris spatulata* [*T. Daintreei*] in the lower part of the Series,† is sufficient to render the correlation of any part of the Clarence Series with the Ipswich Series improbable. It is possible that the sandstones and conglomerates at the base of the Clarence Series may be the equivalents of the Bundamba, but, on the present evidence, I believe that the greater part of the Clarence Series (if not all of it) is to be correlated with the Walloon Series of Queensland.

Fossil plants are present in varying abundance in the various Lower Mesozoic Series of New South Wales. No thorough examination of the flora of the three Stages has been undertaken, and, therefore, the compilation of satisfactory lists of the floras of the different Series is not an easy matter. The following lists have been drawn up from descriptions and lists published from time to time, the majority of the determinations of New South Wales Mesozoic plants having been made by Messrs. R. Etheridge Junr., and W. S. Dun. Names included in square brackets in these lists are conclusions or comparisons suggested by myself to bring, where possible, the New South Wales determinations into line with my own work on the Queensland flora.

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* Carne, Mem. Geol. Surv. N.S. Wales, Geology, No.6, 1908, pp.31-40.
† Carne, *op. cit.*, p.34.

List of fossil plants recorded from the Lower Mesozoic rocks of New South Wales :—

i. Hawkesbury Series.

(*a*) Narrabeen Stage.

Equisetum.
Phyllotheca.
Schizoneura australis.
Alethopteris sp.
Cladophlebis cf. *Roylei.*
Thinnfeldia narrabeenensis
T. lancifolia.
T. odontopteroides.
T. odontopteroides(Hawkesbury type) [= *T. Feistmanteli*].

Thinnfeldia, n.sp.
Sphenopteris sp.
Oleandridium[*Tæniopteris* sp.].
Macrotæniopteris [*Tæniopteris* sp.].
Tæniopteris cf. *McClellandi.*
Ginkgo dilatata var. *lata.*
Rhipidopsis ginkgoides var. *Sussmilchi.*
Araucarites (cones).
Brachyphyllum(?).

(*b*) Hawkesbury Sandstone Stage.

Ottelia præterita.
Phyllotheca concinna.
P. Hookeri.
Equisetum.
Alethopteris.

Thinnfeldia odontopteroides [*T. Feistmanteli*].
Macrotæniopteris.
M. wianamattæ.
Oleandridium lentriculiforme.

(*c*) Wianamatta Stage.

Phyllotheca Hookeri.
P. australis.
Thinnfeldia odontopteroides [*T. Feistmanteli* and *T. odontopteroides*].
Thinnfeldia, small var. *lancifolia*-type.
Cycadopteris scolopendrina.

Macrotæniopteris wianamattæ.
Sphenopteris
Pecopteris(?) *tenuifolia.*
Gleichenia dubia(?).
Alethopteris australis [*Cladophlebis australis*]
Baiera multifida[*B. Simmondsi*]
Pterophyllum(?).

ii. Talbragar Series.

Thinnfeldia odontopteroides.
Thinnfeldia sp.
Neuropteridium australe.
Sphenopteris sp.
Tæniopteris Daintreei [*T. spatulata*].

Podozamites lanceolatus.
P. spathulatus.
P. longifolius.
Podozamites sp.
Taxites cf. *T. planus.*

iii. Clarence Series.

Alethopteris australis [*Cladophlebis australis*].
Thinnfeldia odontopteroides.
Sphenopteris.
Tæniopteris Daintreei [*T. spatulata*].
T. Tenison-Woodsi.

iv. Artesian Series.

Tæniopteris Daintreei [*T. spatulata*].
Thinnfeldia odontopteroides.
Baiera.

The plant to which special prominence has been given, in dealing with Australian Lower Mesozoic strata, is *Tæniopteris spatulata* [*T. Daintreei*]. This plant is of very widespread occurrence in Eastern Australia, and seems to be a reliable indicator of age. In Queensland, it is found abundantly in the Walloon Series, but not in the Ipswich Series. In New South Wales, it is found in the Clarence Series, Artesian Series, and Talbragar Series, but not in any stage of the Hawkesbury Series. There is no doubt of the identity of both the Clarence and Artesian Series with the Walloon Series, for they are continuous in the field. The Talbragar Series is unconformable on the Hawkesbury Sandstone, and the presence of *Tæniopteris spatulata* in the Talbragar Series indicates the relation of this Series to the Walloon Series; the occurrence of a *Taxites* comparable with *T. planus* is additional evidence for assigning the two Series to the same period.

The next point to be considered is the relation of the rocks of the Hawkesbury Series to the other Lower Mesozoic rocks. There is no doubt that the Hawkesbury Sandstone is older than the Talbragar Series, and, therefore, older than the Walloon Series. What then is the relation between the Ipswich Series and the Hawkesbury Series? In the following Table are included the species of plants in the stages of the Hawkesbury Series which are identical or closely comparable with species in the Ipswich Series, the allied species in the Ipswich Series being indicated in square brackets.

TABLE ix.

Table showing species in the Hawkesbury Series identical or closely comparable with species in the Ipswich Series.

Narrabeen Stage.	Hawkesbury Sandstone Stage.	Wianamatta Stage.
Thinnfeldia lancifolia	*Thinnfeldia odontopteroides* [= *T. Feistmanteli*]	*Phyllotheca australis*
T. odontopteroides	*Oleandridium* [*Taeniopteris*] *lentriculiforme*	*Thinnfeldia odontopteroides* [— *T. odontopteroides* and *T. Feistmanteli*]
T. odontopteroides (Hawkesbury type) [= *T. Feistmanteli*]	*Macrotaeniopteris* [*Taeniopteris*] *wianamattae*	*T. lancifolia*
Cladophleiis cf. *Roylei*		*Macrotaeniopteris* [*Taeniopteris*] *wianamattae*
		Alethopteris [*Cladophlebis*] *australis*
		Baiera multifida [*B. Simmondsi*]
		?*Pterophyllum*(?) sp.

It must be admitted that the flora of the Hawkesbury Series has been but imperfectly determined, but what evidence there is, goes to show that the Ipswich flora is much more closely related to that of the Wianamatta Stage than to either the Hawkesbury Sandstone Stage or the Narrabeen Stage.

Having considered the evidence of the fossil plants, we may now briefly deal with the evidence provided by the other fossils in these Series.

The results so far published, of the examination of fossil insects* from the Ipswich Series and Wianamatta Stage, do not give promise of any special value from a stratigraphical point of view, though, no doubt, they are of interest to the entomologist. However, the fact that insects are found, more or less abundantly, in these two Series, and have not yet been discovered in the other Series of Lower Mesozoic rocks, with the exception of *Cicada* (?) *lowei* in the Talbragar Beds, is a point which must be taken into consideration when discussing the correlation of the Series. The insects in the Wianamatta Beds belong to the same Orders as some of those in the Ipswich Series, and, in one case, the same genus is present, but there is no specific identity.

* Queensland Geol. Surv., Publication No.253.

One species of *Estheria* has been recorded from the Ipswich Series (*E. mangaliensis* Jones), and one from the Narrabeen Stage (*E. Coghlani* Cox). The two species are different, and the Ipswich species has been identified by Etheridge* with *E. mangaliensis* from the Damuda Beds (Permian) of India.

Two species of *Unio* (*U. ipsviciensis* and *U. eyrensis*) have been described from the Ipswich Series; and two species of *Unio* (*U. wianamattensis* and *U. Dunstani*) together with two species of *Unionella* (*U. bowralensis* and *U. Carnei*) from the Wianamatta Stage. They are the only pelecypods recorded from the Lower Mesozoic rocks of New South Wales and Queensland.

Fossil fish have been found somewhat abundantly on certain horizons of the Hawkesbury Series, and in the Talbragar Series; and have been described by Dr. A. Smith Woodward.†

From the Talbragar Series, seven species were described, all being new.‡ Regarding the age of this fish fauna, Woodward concludes (*op. cit.*, p.26) "The Talbragar fish-fauna is, therefore, probably not earlier than the Upper Lias, and may be referable to the Lower Oolites."

The results of his examination of the fossil fishes from Gosford and St. Peter's are remarkable. The Gosford horizon is about the junction of the Narrabeen and Hawkesbury Sandstone Stages, whereas the St. Peter's horizon is in the Wianamatta Stage, and is some 900 to 1,000 feet above the Gosford horizon. Regarding the fish-remains from Gosford, Woodward§ concludes: "So far as can be determined from the fishes, therefore, the Hawkesbury beds may be regarded as homotaxial with the Keuper of Europe, or, at latest, with the Rhætic; and, on the whole, the present writer is inclined to adopt the first of these interpretations."

In the case of the St. Peter's specimens, the fish were collected in two types of matrix, viz., an indurated shale or claystone, and a grey mudstone, the former occurring as several bands sepa-

* Geology and Palæontology of Queensland, p.397.

† Mem. Geol. Surv. N. S. Wales, Palæontology, Nos 4, 9, 10.

‡ *Ibid.*, Palæontology, No.9.

§ *Ibid.*, p.55.

rated by the latter. Woodward refers to the fish from the indurated shale as indicating a distinct Permo-Carboniferous age, and those from the grey mudstone as Triassic or Rhætic.* Obviously, great caution must be exercised in using these results for the purpose of correlation.

(*b*) *Victoria.*—The Lower Mesozoic rocks of Victoria comprise series of shales, felspathic sandstones, and mudstones, with occasional conglomerates, which are developed in three areas, viz., South Gippsland, Cape Otway, and Wannon River. Associated with these rocks are coal-seams up to nine feet in thickness. Analyses of the coals are of the same general type as analyses of the Ipswich coals. The flora of some of these beds has been described by Seward,† whose conclusion regarding their age is, that they are approximately the same age as the Inferior Oolite of England, or the Rajmahal Series of India.‡ Occasional additions to the species described by Seward have been recorded by Chapman.

The following list comprises the species described by both Seward and Chapman :—

Marchantites sp.
β*Equisetites wonthaggiensis.*
Equisetites sp.
α*Lycopodites victoriæ.*
Adiantites lindsayoides.
α*Coniopteris hymenophylloides* var. *australica.*
Sphenopteris ampla.
Sphenopteris sp.
Tæniopteris Daintreei.
α*T. Daintreei* var. *major.*
β*T. spatulata* var. *crenata.*
α*Cladophlebis denticulata* var. *australis.*
β*Thinnfeldia odontopteroides.*
Thinnfeldia McCoyi.
Thinnfeldia sp.
Rhizomopteris Etheridgei.
β*Stenopteris elongata.*
β*Stenopteris* sp.
α*Ginkgo* sp.
α*Baiera australis.*
α*B. gracilis.*
Ginkgo (female flowers?).
α*Nilssonia* sp.
Podozamites Barklyi.
P. ellipticus.
β*P. Kidstoni.*
P. longifolius.
α*Araucarites* sp. A.

* Mem. Geol. Surv. N. S. Wales, Palæontology, No. 10, pp. 27, 29.
† Rec. Geol. Surv. Victoria, Vol. i., Pt. 3, 1904.
‡ *Op. cit.*, p. 184.

Araucarites sp. B.
β*Conites* sp.
cf. *Brachyphyllum* sp
β*B. gippslandicum.*
α*Taxites* sp.
β*Palissya australis.*
β*Cheirolepis* (?) *setosus.*
β cf. *Albertia australis.*
Carpolithes sp. A.
Carpolithes sp. B.

The species marked β are recorded by Chapman, in addition to those described by Seward.

Of the species in this list, those marked with α (10 in number) are similar to types occurring in the Lower Oolite of England.

In the Victorian Lower Mesozoic rocks, a tooth and scales of *Ceratodus* have been found, and also a claw of a dinosaur. One species of *Unio* (*U. stirlingi*) occurs in these beds.

Although the number of species of plants common to the Victorian and Queensland Lower Mesozoic rocks is small, there is no doubt that the Victorian flora resembles the Walloon flora much more than it does the Ipswich flora. A few species, *e.g.*, *Tæniopteris Daintreei* (= *T. spatulata*), *T. Daintreei* var. *major*, and *Cladophlebis denticulata* var. *australis* (= *C. australis*) are identical with forms of the Walloon Series; while others, as *Sphenopteris ampla*, *Baiera gracilis*, cf. *Brachyphyllum* sp., and *Taxites* sp., are closely allied to forms found in the Walloon Series. The occurrence of *Tæniopteris spatulata* and the conifers, *Araucarites*, *Brachyphyllum*, and *Taxites* is sufficient to show clearly, that this flora is not to be compared with that of the Ipswich Series. There appears to be no doubt that the Victorian Mesozoic Coal-Measures are to be correlated with the Walloon Series in Queensland, and its equivalents in New South Wales.

(*c*) *South Australia.*—In South Australia, the strata of Lower Mesozoic Age comprise the south-western margin of the Great Australian Artesian Basin, and an outlier of this preserved as a faulted basin in the neighbourhood of Leigh's Creek. The Leigh's Creek basin is quite isolated, and surrounded by rocks of Upper Cambrian Age; the basin is 16 miles long, and has a maximum breadth of 6 miles; the total thickness of strata in it exceeds 2,000 feet of shales and carbonaceous shale, with bands of limestone and sandstone, and a belt of very hydrous coal, 48 feet thick.

Recent developments in Queensland show that large areas of sandstone on the margin of the Artesian Basin, which have previously been regarded as of Cretaceous Age, must now be considered as equivalents of the Walloon Series. Future work may show that the marginal portions of the Artesian Basin in South Australia represent the same sandstones, though these are all at present mapped as Cretaceous. Near the margins of the basin, the water-bearing sandstones obviously approach close to the surface, as shown from bore-records, and it seems more probable that they outcrop, than that they are overlapped by the Cretaceous.

The fossil plants recorded from the South Australian Lower Mesozoic rocks are:—

Thinnfeldia odontopteroides [? = *T. Feistmanteli*].
T. media [? *T. lancifolia*].
Macrotæniopteris wianamattæ.
Tæniopteris fluctuans.
Alethopteris sp.
Equisetum 2 spp.
Frenelopsis(?).
Anthrophyopsis(?) sp.ind.

Phyllopteris Feistmanteli occurs at Ooroowilanie Swamp, about 100 miles north of Leigh's Creek, but this may be in the Cretaceous rocks. This list has been drawn up by Howchin,* mainly from determinations by Etheridge. *Unio eyrensis* also occurs abundantly in the same rocks.

This list of plants does not provide any very conclusive evidence regarding correlation with other Australian strata. There seems no reason for not considering the Leigh's Creek basin as an outlier of the Artesian Series; and, further, the identity of the Artesian Series with that of New South Wales and the Walloon Series in Queensland is hardly open to question.

(*d*) *Western Australia.*—Western Australia provides the only Australian example of marine and freshwater fossils of Lower Mesozoic Age occurring in association with one another. The exact relation which the plant-bearing beds bear to those with marine fossils is not clearly stated, but it may be inferred from a study of Bulletins 36, 38, and 50 of the Geological Survey of Western Australia.

* British Assoc. Adv. of Science: Handbook of South Australia, 1914, p.225.

The marine fossils fix the age of the Lower Mesozoic of Western Australia as Jurassic, and Etheridge refers those from the Greenough River to the Oolite.* The Jurassic rocks cover a large area in the Champion Bay district, near Geraldton, particularly between the Greenough and Irwin Rivers. According to Gibb Maitland, they consist of "oolitic limestones, clays, sandstones (which are often ferruginous), grits, conglomerates, and lignites."† They are horizontal or gently undulating, and their thickness has been proved to the extent of 2,000 feet, by bores in the Champion Bay district.

From these rocks, Arber‡ has described *Otozamites Feistmanteli*, and a coniferous fragment from near Mingenew: and he has pointed out the resemblance of these to fossils from Talgai, Darling Downs, and Rosewood, west of Rockhampton in Queensland.

Examples of fossil plants in close association with marine fossils are noted by Campbell.§ Speaking of Mt. Hill,‖ he says, "Fossil stems of a plant, apparently a species of Equisetaceæ, and Palm or *Otozamites* stem-scales and pieces of wood occur in the sandstones and grits of the north side."

"A limestone band occurs at about 100 feet below the summit of the hill, and can be well seen on the fence-line, 10 chains west of the summit. Here, numerous Jurassic fossils occur in an excellent state of preservation. On the ridge, also, extending north from the summit, there is a fossiliferous, fine-grained sandstone."

The results of Dr. Arber's examination of the plants from Mingenew were apparently available to Mr. Campbell, since he quotes (p.58) Arber's conclusions, so it may be presumed that the plants from Mt. Hill are similar to those from Mingenew. On Plate 5 of the same work, in the vertical section of the Don-

* Geol. Surv. West Australia, Bulletin 36.

† Geol. Surv. West Australia, Bulletin 50, p.21.

‡ *Ibid.*, Bulletin 36, p.25.

§ *Ibid.*, Bulletin 38.

‖ *Op. cit.*, p.60.

gara bore, "fossils" are indicated in shale at 535 feet, and "plant-remains" at about 1,300 feet.

Although the information is scanty, it may be concluded that comparatively flat-bedded rocks of Jurassic Age, and of considerable thickness, cover a large area in Western Australia; that these beds contain both marine and plant-fossils, and that the plant-fossils include equisetaceous stems, *Otozamites* and coniferous fragments, and also petrified, coniferous wood.

Where definite evidence for accurate correlation is scanty, as in the present case, all possible indications must be considered; and, at the same time, caution must be exercised in drawing conclusions. In comparing these Western Australian Jurassic rocks with the Lower Mesozoic strata of Queensland, the following points stand out.—(*a*) In the Western Australian Jurassic, the only definitely determined plant is *Otozamites Feistmanteli*, which occurs in a fine-grained, ferruginous sandstone, possibly of Oolite age; (*b*) in Queensland, fossil plants are abundant in the Lower Mesozoic strata, but the genus *Otozamites* occurs only in the Walloon Series, and usually in a fine-grained, ferruginous sandstone, which is of very wide occurrence;* (*c*) the species *Otozamites Feistmanteli* occurs both in the Western Australian Jurassic and in the Queensland Walloon Series.

The indications, then, point to the probability that the Walloon Series is homotaxial with the Jurassic strata of Western Australia. If, as the author believes, the development of the fine-grained, ferruginous sandstone containing *Otozamites Feistmanteli* indicates peculiar conditions under which deposition took place, then there is the further indication that the two Series are synchronous.

(*e*) *Tasmania*.—A rich, Lower Mesozoic flora is present in the strata of that age in Tasmania. This flora, however, has been untouched for many years, and the existing descriptions and figures by Johnston are too imperfect to be used for any purpose of definite correlation. In addition, Mr. Twelvetrees, Government Geologist of Tasmania, kindly informed me that the rela-

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* See above, p.50.

tions of the Lower Mesozoic strata in Tasmania to one another are not yet definitely settled. No attempt will be made here, therefore, to correlate any of the Tasmanian Lower Mesozoic rocks with the other Australian occurrences. One point may be noted. There appears to be an absence of *Tæniopteris spatulata* in the Tasmanian strata, and this may indicate that they are older than Jurassic.

Opinions have been expressed regarding the age of Tasmanian strata. Chapman* suggests that it may be possible to divide the "Upper Coal-Measures" of Twelvetrees into an older and a younger series. He concludes, "The Jurassic flora of the Tasmanian localities, Jerusalem, Fingal, Spring Hill, York Plain, Hamilton, Richmond, New Farm, Sandfly, Recherche, South Cape, Longford, etc., appears to contain an assemblage which, with some few exceptions, as *Sagenopteris* and *Phœnicopsis*, is practically identical with that of the plant-bearing strata of Jurassic age in South Gippsland, Cape Otway, and Western Victoria"

Professor David† classes them provisionally "as Upper Trias or Passage Beds into the Jurassic proper," whereas W. S. Dun‡ regards them as equivalents of the Victorian Jurassic.

Mr. Twelvetrees points out that the evidence of the fossil flora in Tasmania, as far as it goes, is slightly in favour of a Rhætic age. He also considers that some of the Tasmanian occurrences are the equivalents of the Clarence and Talbragar Series in New South Wales.§

Lower Mesozoic fossil plants are known from a number of localities in New Zealand, but, in view of the fact that an examination of them has recently been carried out by Dr. E. A. Newell Arber (the results not having been published yet||), it is deemed inadvisable to discuss them at this stage.

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* Records Geol. Surv. Victoria, iii., Pt.2, 1912, p.223.

† British Assocn. Adv. Science, Geology of the Commonwealth, p.277.

‡ *Ibid.*, p.297.

§ Geol. Surv. Tasmania, Bulletin 20, 1915, pp.14-16.

|| Issued in February, 1918, too late for consideration in the present paper.

(f) Summary. - The results of these comparisons of the Queensland, Lower Mesozoic rocks with those of the other Australian States, may be summarised in tabular form thus :—

TABLE X.

Table showing correlation of the Lower Mesozoic Strata of Australia.

	Queensland.	New South Wales.	Victoria.	S. Australia.	W. Australia.	Tasmania.
Jurassic (Lias-Lower Oolite)	Walloon Series	= Clarence Series, Artesian Series, Talbragar Beds	= Jurassic of S. Gippsland, Cape Otway, and Wannon River.	= Leigh's Ck. Basin.	= Marine strata in Geraldton, Champion Bay, and (?) C. Riche Districts.	Possibly there are representatives of both Jurassic and Triassic in the Lower Mesozoic of Tasmania.
Triassic (Rhætic or Upper Triassic)	Bundamba Series					
	Ipswich Series	Wianamatta Beds				
?Lower Triassic		Hawkesbury Sandstone				
		Narrabeen Beds				

Geological History.

In discussing the conditions which existed during Lower Mesozoic times in Queensland, reference must be made to the conditions, as far as we know them, towards the close of the preceding Permian (Permo-Carboniferous) Period. The latest sediments of this latter period are the Upper Coal-Measures in both New South Wales and Queensland. In New South Wales, the Newcastle or Upper Coal-Measures were formed in a large basin. In an earlier paper,* I have attempted to show, in a general way, the distribution of land and sea in New South Wales during the various stages of the Permian (Permo-Carboniferous)† Period, and have suggested that the successive stages within the period might have been produced by a tangential force acting towards the continental mass of Australia in a W. by S. direction.

The close of the Palæozoic era in Northern New South Wales and Southern Queensland was accompanied by extensive intrusions of granitic masses. In the New England and Stanthorpe-Warwick districts, these intrusions have resulted in extreme folding of the Permian (Permo-Carboniferous) strata, but have not affected the sediments of the Walloon epoch. The age of the intrusions is definitely between the upper marine sediments of the Permian System and the Walloon Series. The Permian (Permo-Carboniferous) sedimentary strata have been extremely folded and contorted, and converted into slates resembling, in general appearance, rocks of greater age than Permian; their age, however, has been fixed beyond doubt by the occurrence in them of marine fossils in the Drake district, and near Warwick.‡

* Proc. Linn. Soc. N. S. Wales, 1913, xxxviii., pp.139-145.

† It has recently been suggested by Professor David and Mr. W. S. Dun (British Assocn. Adv. Sci., Australia, 1914: Report, p.379; and Federal Handbook on Australia, p.267) that perhaps the term Permo-Carboniferous in Australia should be replaced by the term Permian. Without going into reasons here, it may be stated that the author is entirely in accord with the suggestion, and, for the purposes of this paper, proposes to write the name thus: Permian (Permo-Carboniferous).

‡ Andrews, "Report on Drake Gold and Copper Field," Geol. Surv. N. S. Wales, Mineral Resources, No.12, 1908.

Further north, in the Gympie district, rocks of similar age are also folded and metamorphosed to much the same extent as in the districts just mentioned.

A word of caution must be expressed here regarding the so-called "Gympie" strata. The results of fieldwork carried out by the officers of the Queensland Geological Survey tend to show that many rocks have, in the past, been referred to the Gympie Series without sufficient evidence; these are gradually being sorted out by the Geological Survey, and put in their proper position; and they have been found to include representatives of the Carboniferous and Devonian Systems, in addition to true Permian (Permo-Carboniferous) strata. Care must be exercised, therefore, when dealing with rocks classed as Gympie.

In the Gympie district, where undoubtedly Permian (Permo-Carboniferous) sedimentaries are much altered, there are granitic, intrusive masses whose age is not directly determinable. It seems a reasonable suggestion that they are of similar age to the New England intrusions, and that they have been responsible (at least in part) for the folded and altered condition of the Gympie rocks.

Further north and north-west in Queensland, the Permian (Permo-Carboniferous) rocks [Bowen River coalfield, Dawson-Mackenzie coalfield, etc.] appear to be normal, and not to have suffered any considerable folding as the result of the intrusion of large plutonic masses.

In the distribution of the Permian (Permo-Carboniferous) rocks of New South Wales and Queensland, then, there are to be noted the following important points. Sediments of this age are known from Southern New South Wales to Northern Queensland; normally, these sediments are unaltered, and apparently have not been subject to extreme folding-forces; in the central part, however, (from New England to the Gympie district) the intrusion of extensive, granitic masses has resulted in extreme folding and metamorphism of sediments of this age, which, as a result, resemble strata of much greater age than the normal Permian (Permo-Carboniferous) strata of Eastern Australia.

These extensive intrusions probably resulted in the elevation of the areas affected, to a much greater altitude than the neighbouring areas.

The Lower Mesozoic rocks of Eastern Australia appear to have been deposited in a series of basins, which were not all developed at the one time. The sediments deposited in these basins are, with a single exception (*supra*, p.38), freshwater accumulations, and this fact tends to show that the basins must have had some outlet: otherwise, the bodies of water would comparatively soon have become salt. Regarding deposits formed in basins in this manner, we may note that Suess quotes Richthofen's distinction between central and peripheral types of drainage as illustrated by salt and coal. He says, "Salt with gypsum corresponds to a closed drainage system or central position; coal, when found in extensive freshwater basins, corresponds to the open outflow, without which no accumulation of water could maintain for long its original composition."* The latter part of this statement seems to admit of no contradiction, and it applies to the basins in which the sediments of Lower Mesozoic age in Eastern Australia were deposited. We shall consider later the positions of the outlets for the various basins.

The earliest basin developed was that in which the Hawkesbury Series of New South Wales was deposited. In the central portion of this basin there appears to be stratigraphic conformity between the Upper Coal-Measures, and the Narrabeen Stage of the Hawkesbury Series. Nearer the margins, however, there is unconformity. In addition, there is a very distinct palæontological break, only a few forms persisting from the lower to the upper. The unconformity between these two Series is one which involves a definite interval of time, but not any considerable movement. The time-interval must have been sufficiently long for the Mesozoic flora of the Narrabeen Stage to have almost completely replaced the typical Palæozoic flora of the Upper Coal-Measures

The basin in which the Narrabeen Stage was deposited was produced by a gradual subsidence, which apparently continued

* Suess, "The Face of the Earth," iii., p.312.

throughout a long period during which the Narrabeen and Hawkesbury Sandstone Stages were deposited. The area of deposition increased gradually during this time, the Hawkesbury Sandstone Stage covering a much greater area than the Narrabeen Stage. During the early stages, volcanic activity appears to have been in evidence, as indicated by the development of tuffaceous rocks in the Narrabeen Stage. The thickness of the sediments deposited in this basin reaches a maximum of about 3,000 feet, made up of a maximum of 2,000 feet of the Narrabeen Stage, and 1,000 feet of the Hawkesbury Sandstone Stage.

The Hawkesbury Sandstone Stage is apparently conformable with the Narrabeen Stage. The existence of breaks, which do not show as very marked unconformities, must, however, always be borne in mind. Writing on this point, Schuchert remarks,* "The easily seen, marked unconformities . . . . are of course accepted at full face-value; but the many more apparently conformable and yet broken contacts, the disconformities, are generally overlooked, or when seen are generally undervalued. . . . In regard to the breaks, the statement can be made that there are at least ten disconformities for every known angular unconformity."

These statements may be applied to both the Permian (Permo-Carboniferous) and Mesozoic Systems of Australia, within which, apparent conformity appears to be general, but where there are quite a number of palæontological breaks.

During the time in which the Narrabeen and Hawkesbury Sandstone Stages were deposited, probably the rest of Australia, which at that time was of greater extent than to-day, was dry land.

Between the Hawkesbury Sandstone Stage and the Wianamatta Stage there is a distinct break. The Wianamatta beds have been deposited on the eroded surface of the Hawkesbury Sandstone, which must, therefore, have been elevated, exposed to denudation, and again submerged before the succeeding beds were laid down. In addition, the extent of the Wianamatta beds was much more limited than the Hawkesbury Sandstone.

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* Bulletin Geol. Soc. America, xxvii, 1916, p.497.

Our studies of the fossil floras indicate that the Ipswich Series in Queensland was laid down at the same time as the Wianamatta Stage in New South Wales. The strata of this Series were laid down over a comparatively restricted area in Southern Queensland, though it is not possible to obtain an accurate idea of its exact extent. Parts of the areas bordering the basin in which the Ipswich Series was deposited were probably very elevated, *e.g.*, the Stanthorpe-Warwick, and the Gympie Districts, the extent of the elevation having been due to the extensive intrusions of granite at the close of the Palæozoic era.

It is probable, also, that part of the Lower Mesozoic sediments of Tasmania was deposited contemporaneously with the Wianamatta Stage in New South Wales, and the Ipswich Series in Queensland.

The Bundamba Series, which follows the Ipswich Series in Queensland, has no equivalents, so far as we know, in New South Wales; apparently, sedimentation in the main Hawkesbury Basin came to a close with the end of the Wianamatta Stage. Later sediments in that State were laid down to the north and north west.

In Queensland, the dominant movement from the beginning of the Ipswich epoch was a subsidence. This movement was not continuous; there were, at least, breaks represented by the base of the Bundamba Series and of the Walloon Series, and there may have been further breaks within the Series. At the time of these breaks there was probably a cessation of sedimentation, accompanied by a slight uplift before the downward movement reasserted itself; the predominance of the downward movement is proved by the ever-increasing area covered by the Lower Mesozoic sediments until, towards the close of the Walloon epoch, the greater part of Queensland was probably covered by enormous stretches of fresh water. The portions of Queensland which were not submerged during the Walloon epoch (Jurassic) include the north-western corner of the State, an area in the neighbourhood of Hungerford on the New South Wales border, and probably areas to the east of the present Main Divide, which had been considerably elevated as a result of movements accompanying the intrusion of extensive granitic masses at the close of the Palæozoic era. It is impossible to define these latter areas at present, but they include the Stanthorpe and Gympie districts, and probably some of the present coastal portions of Queensland north of Rockhampton.

The area over which deposition of the Walloon Series took place extended into New South Wales and South Australia; and its boundary probably agreed fairly closely with the margin of the Great Australian Artesian Basin; it is from sandstones in the Walloon Series and its equivalents, that the great bulk of the artesian water is obtained, so that, although these are not known to outcrop along the southern margin of the Artesian Basin, their presence is known, and they are apparently overlapped by the Lower Cretaceous strata.

It may be remarked here, that it is only comparatively recent work that has shown the sandstones forming the intake in Queensland to be of Walloon age. In view of this, it is possible that outcrops on the southern and western margins of the Basin may, in the future, be shown to be of the same age, though at present mapped as Cretaceous.

The Clarence Series represents deposition in the south-eastern portion of the same basin. The Talbragar beds seem to represent deposition in a small, isolated lake.

In South Australia, the small, faulted basin at Leigh's Creek probably represents an outlier of the main occurrence further north.

Contemporaneously with the Walloon Series also, there were deposited the Jurassic sandstones, etc., of South Gippsland, Cape Otway, and the Wannon River areas in Victoria, and possibly also portion of the Lower Mesozoic strata of Tasmania. At the same time, marine sediments were laid down in Western Australia, and, associated with these, there are a few plant-remains.

The close of the Jurassic in Australia was not marked by any violent movement. In Queensland, New South Wales, and South Australia, the Jurassic rocks are followed by Cretaceous marine strata (Rolling Downs Series) without any observable unconformity. Palæontologically, however, there is a very marked break, and there is also generally a lithological distinction. The Cretaceous sea represents a transgression from the north, and covered the greater portion of the Jurassic strata over what is now the Great Artesian Basin, and, as shown in Text-fig.6, this transgression probably divided the Australian continent in two. The present Main Divide in Queensland was probably elevated, and became a land-area practically throughout its whole length in Cretaceous time, and has remained essentially so to the present day. On the west, the Cretaceous sea covered the area of the Artesian Basin as already mentioned, while, on the east, there are Cretaceous marine deposits between Maryborough and Bundaberg reaching a thickness of 1,000 feet. It is impossible to determine the exact extent of these to the east. The marine Cretaceous, both in western Queensland and in the Maryborough district, are followed by Cretaceous freshwater deposits known as the Winton Series and Burrum Series, respectively.

Lower Mesozoic Palæogeography of the Australasian Region.

Published maps indicating the geography of the Australasian region during Mesozoic times are few in number.

Perhaps the oldest is that of Neumayr, which has been continually quoted and figured by later writers, including Jensen* and Hedley.† The latter‡ also prepared a map to show the Queensland coast at the close of the Mesozoic era. Jensen§ has published a series of maps showing the distribution of land and sea in the Australian region at various periods, including one in Triassic time. Recently, Schuchert|| has published a series of palæogeographic maps of Oceania, including one in Triassic time, and one in Cretaceous.

The important general feature of these maps is that they show

* Proc. Linn. Soc. N. S. Wales, 1908, xxxiii., p.507.

† Report Aust. Assoc. Adv. Science, xii., 1909, p.332.

‡ *Op. cit.*, p.333.

§ Proc. Roy. Soc. Queensland, xxiii., Pt.2, 1912.

|| Amer. Journ. Science, xlii., 1916, p.99.

a coast-line not a great distance east of the present position of the eastern coast of Australia. This coast-line is the western shore of a long gulf running from the south in a general meridional direction between Australia and New Zealand. Neumayr called this the Gulf of Queensland. Schuchert's map shows the extension of this gulf further north to about the latitude of New Caledonia, when it turns to the east and again joins the ocean.

Evidence as to the existence, or otherwise, of this gulf is scanty. Hedley* says, "According to Neumayr, a meridional crease in the earth's crust produced, in Jurassic times, a gulf, which he called the Gulf of Queensland, whose western shore transgressed the present east Australian coast." The most important piece of evidence indicating the existence of this gulf is the presence of an impoverished fauna of Foraminifera and Ostracoda in the upper beds of the Wianamatta Stage in New South Wales (*supra*, p.38). This is positive evidence of marine or estuarine conditions in the Wianamatta Basin (probably during late Triassic time). There is no evidence at all to show that this gulf transgressed the present east coast of Australia during Jurassic time; it is certain that there are no evidences of Jurassic marine deposits in Eastern Australia.

The gulf was probably more or less coincident with the present position of the Thomson Trough; but whether the Thomson Trough is as old as Lower Mesozoic, is difficult to determine.

The palæogeography of the Australasian region involves a consideration of the structure of the south-western Pacific region. Structural studies of this region have been made by a number of geologists, including Dana, Suess, Gregory, Marshall, and Schuchert.

Marshall has pointed out that some of the earlier studies were based mainly on the geographic distribution of the island-chains, without much knowledge of structure. He has very rightly contended that conclusions drawn from such distribution may be quite erroneous.

Marshall has argued that "the real boundary of the south-west Pacific passes through New Zealand, Kermadec, Tonga,

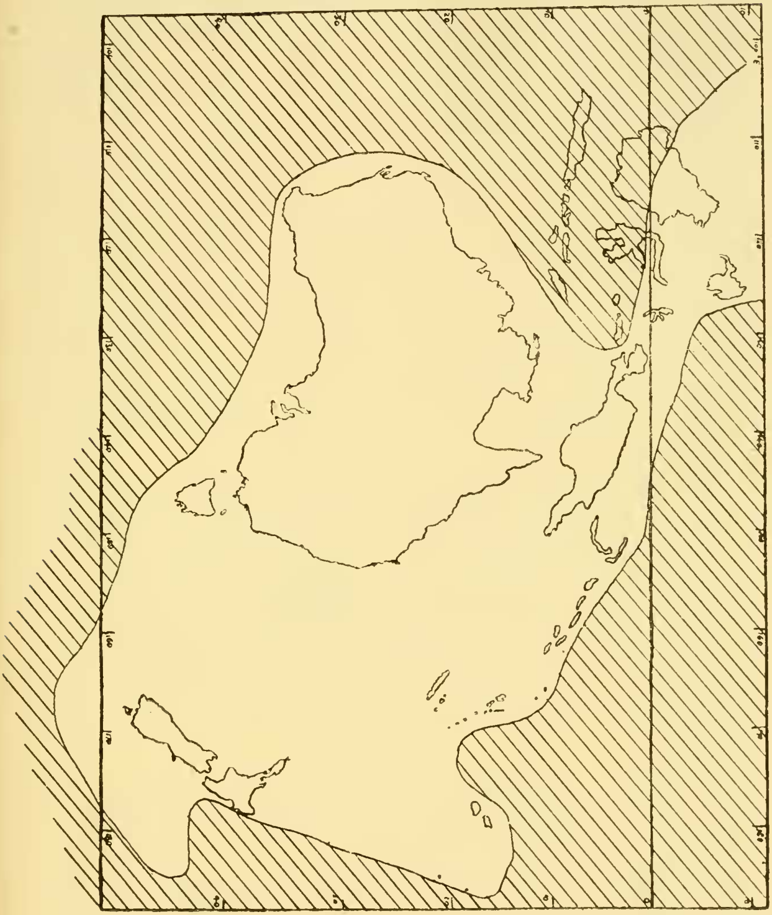
* Report Aust. Assoc. Adv. Science, xii., p.331.

Fiji, New Hebrides, Solomon, and on to the Admiralty Islands."* This line would then be the eastern boundary of the continental mass of which Australia, New Caledonia, New Zealand, etc., are remnants. Within this continental region there are a number of great deeps, *e.g.*, the two Solomon Island deeps (the northern one named the Planet Deep, the other unnamed) and an unnamed deep between the New Hebrides and New Caledonia. A discussion, which the author had recently with Rev. Father Pigot, of Riverview College, produced some facts which seem directly to concern the question of these deeps. The seismometers at the Riverview College observatory have, within the past few years, recorded a number of earthquake-shocks, and Father Pigot has calculated the positions of origin of these shocks. He kindly informed me that quite a large percentage of the shocks recorded had their origin along a line from Kermadec, through the deep between the New Hebrides and New Caledonia, the Planet Deep, and the Swire Deep (east of the Phillipines). The prevalence of earthquake-shocks emanating from this line of deeps is probably connected with faulting-movements, and it may reasonably be argued that these movements are probably a continuation of those which produced the deeps, and, therefore, that these deeps are of very recent origin. If this is so, we have, in these earthquake-records, evidence which supports Marshall's contention as to the true margin of the south-west Pacific. Marshall's conclusions in this respect seem reasonable; and Text-fig.2 (p.105) indicates the probable limits of the continental mass about the beginning of Mesozoic time; this map has been drawn-up mainly from the works of Marshall and Schuchert, already quoted.

This continental mass was connected with Asia about the beginning of Mesozoic time, and it may have been continuous with Gondwanaland. The breaking down of Gondwanaland commenced in early Mesozoic time, and the permanent enlargement of the Pacific basin probably commenced about the same time. There are marine Triassic rocks both in New Caledonia and New Zealand—evidences of epicontinental seas—but there is no marine deposit of Triassic age known on the present Aus-

* Report Aust. Assoc. Adv. Science, xiii., 1911, p.99.

tralian Continent. The distribution of land and sea during Triassic time in this region appears to me to be as indicated in



Text-fig.2.

Map showing the approximate limits of the Continental Mass, of which Australia, New Zealand, New Caledonia. &c., are remnants.

Text-fig.3(p.107). Speaking of the Triassic marine deposits of New Caledonia and New Zealand, Marshall* expressed the opinion,

* Geology of New Zealand, 1912, p.185.

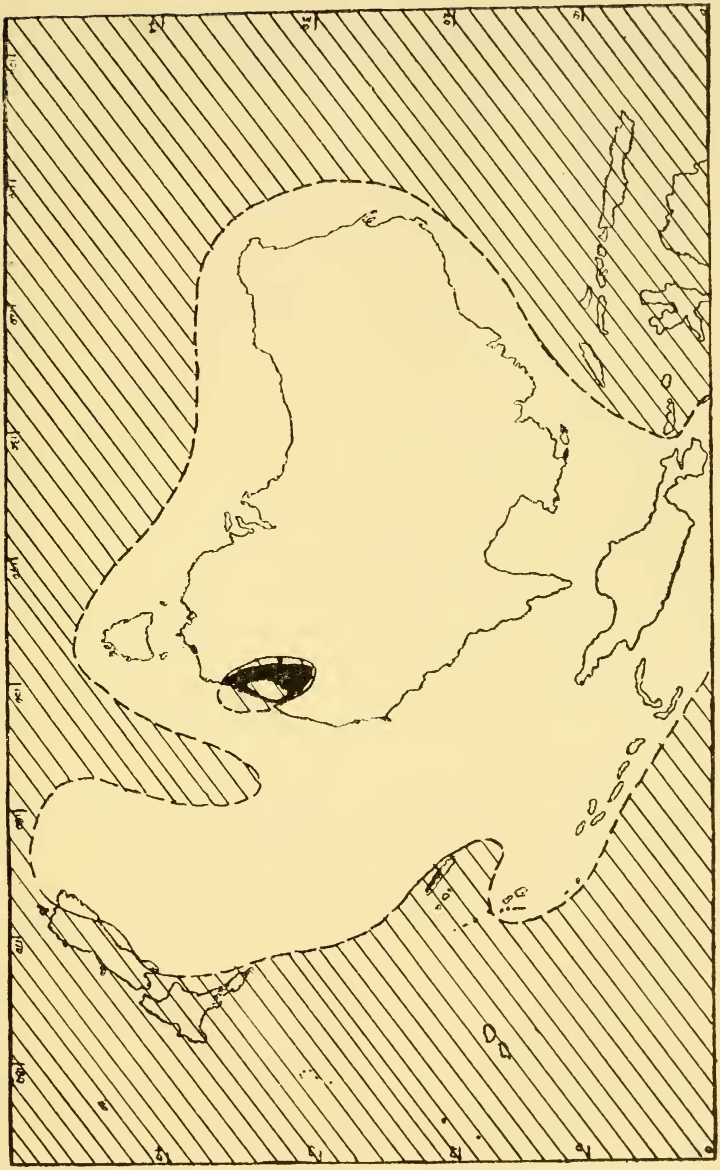
that it cannot be definitely decided whether they represent coastal deposits on an eastern or western coast. If the boundary of the true Pacific basin on the south-west be the line stated, it seems more probable that they represent deposits along the eastern coast of a continent.

The evidence for the existence of the gulf, which Neumayr called the Gulf of Queensland, is not very definite.

The continued deposition of freshwater sediments in the Hawkesbury basin, indicates a continuance of freshwater conditions in this basin over a long period, and there must have been some outlet, as noted above (*see* p.98). As far as we know, there is no possibility of an outlet to the north, south, or west, and, in view of the presence of a foraminiferal and ostracodan fauna in the upper portion of the Wianamatta Stage, it seems probable that the outlet connected with an arm of the sea, such as the Gulf of Queensland. The exact extent of the gulf is purely conjectural.

During the time when the Wianamatta Stage in New South Wales, and the Ipswich Series in Queensland were being deposited, the Gulf of Queensland probably had its maximum extension in a northerly direction. At this time, there were two small basins in which the Wianamatta Beds and the Ipswich Series respectively were deposited. Both these basins may have had outlet to the Gulf of Queensland. Text-fig.4 (p. 109) indicates a probable distribution of land and water at this time.

In Jurassic time, there is no clear evidence to show the existence of the Gulf of Queensland. There are marine Jurassic rocks in New Caledonia. In New Zealand, in the south of the South Island, there are freshwater and marine strata of Jurassic age associated with one another, indicating probably oscillation of marine and fluviatile deposition in a coastal region. In the North Island, in the Kawhia-Waikato district, there are marine Jurassic rocks, and there are also records of fossil plants (Jurassic) from the same district. This, again, indicates a probable coastal region.



Text-fig. 3.

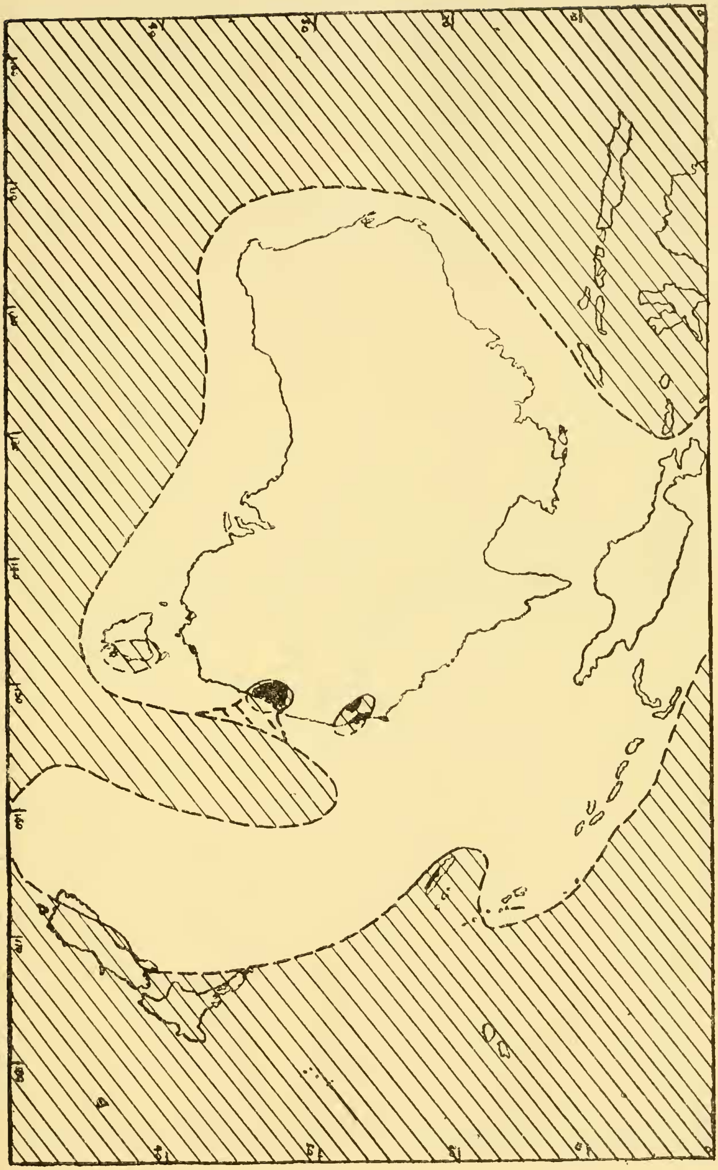
Map showing the distribution of land and water in the Australasian Region in early and middle Triassic time. (Solid black represents the present known extent of strata).

The Jurassic rocks of Victoria and Tasmania are freshwater deposits, and probably extended some distance east of the present coast. The Jurassic strata of New South Wales and Queensland extend right to the extreme north of the latter State, and there are marine Jurassic strata in New Guinea (Strickland River). This seems to indicate that these Jurassic rocks were laid down in a large basin, which had some outlet to the north. Another point which strengthens this, and is against the existence of the Gulf of Queensland during the Jurassic period, is the enormous amount of sediment represented by the continuous Jurassic strata of New South Wales and Queensland. These beds must average some thousands of feet in thickness over an area of some hundreds of thousand square miles, and must represent denudation of a large area. That the drainage to this basin was limited on the north, west, and south, is easily shown, for, in these directions, we know the regions of synchronous deposition, and the divides separating these from the Walloon basin do not allow of a very extensive area from which the sediments may have been derived. There is left, then, only extension to the south-east and east to any very large extent, and, if this was the case, there seems little possibility of the existence of the Gulf of Queensland.

These considerations have governed the drawing up of Text-fig.5 (p.111) showing the distribution of land and sea during Jurassic time.

The Thomson Trough, which lies to the east of Australia, may have been of comparatively recent origin. The east coast of Australia has been subject to folding since Lower Cretaceous, and to considerable faulting during Cainozoic; and it does not seem improbable that the Thomson Trough is a result of these movements. Schuchert* concludes his study of continental fracturing and diastrophism in Oceania thus: "To sum up, we may say that the bottom of the Pacific Ocean in the region of greater Australasia seemingly became more and more mobile with the Lower Carboniferous and especially during the Jurassic and Cretaceous. During this very long time, the eastern half of

* Amer. Journ. of Science, xlii., 1916, p.104.



Text-fig. 4.

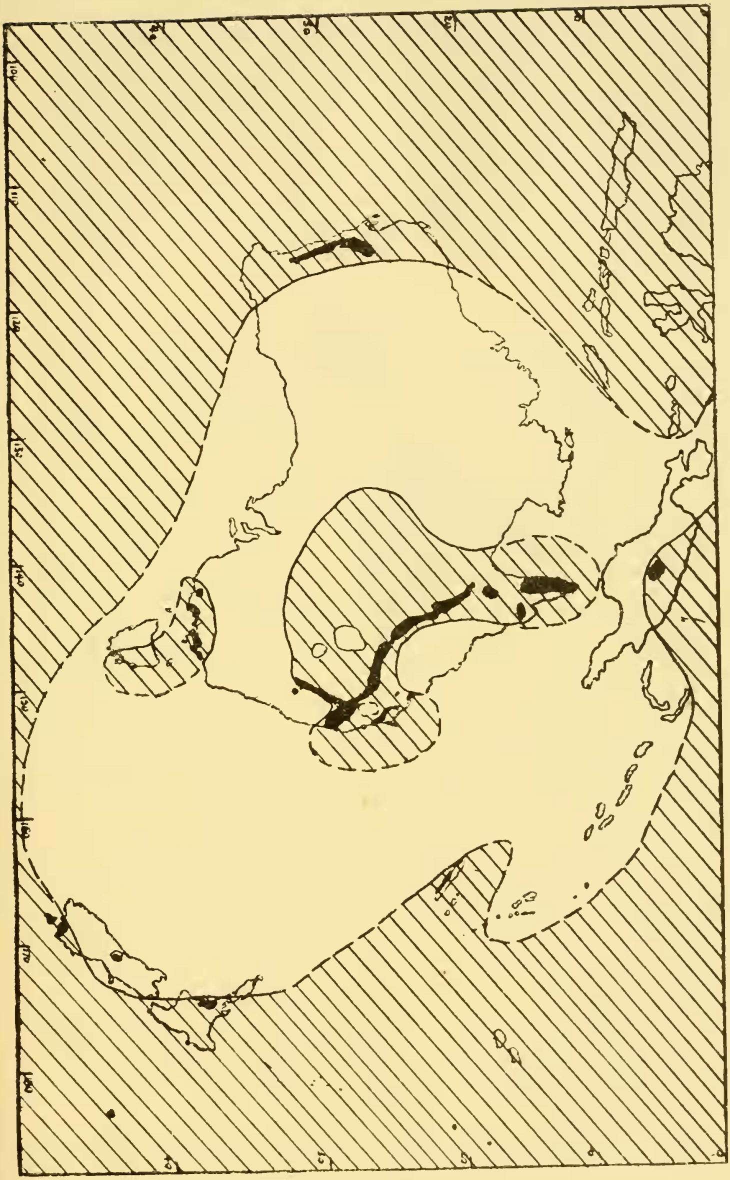
Map showing the distribution of land and water in the Australasian Region during Upper Triassic time (?Keuper or Rhætic). (Solid black represents the present known extent of strata).

the Australian Continent, a land about 1,800 miles east and west and 2,200 miles north and south, was folded into a series of parallel ridges trending north-west and south-east, nearly all of which went down more and more beneath the level of the sea to a maximum depth of about four miles and an average depth of between one and two and a half miles. Small parts of the ridges still protrude above the ocean (at least New Caledonia), but most of what we see are the volcanoes that have built themselves up above the folded rocks to the level of the sea."

This statement gives a general outline of the geological history of this region, but the stress laid on the Jurassic as a period of folding does not appear to be justified. As far as our present knowledge goes, the periods during which folding-forces have been effective since the Carboniferous are Permian (Permo-Carboniferous), late Cretaceous, and possibly late Cainozoic. The Permian strata of New South Wales indicate folding with axes approximately N. by W.; the Triassic, Jurassic, and Lower Cretaceous all show a general stratigraphical conformity, and have all been affected to the same extent by a folding which was later than Lower Cretaceous and earlier than Cainozoic, the direction of the axes of folding being about N.30°W.; the Cainozoic rocks in the Ipswich District have been subject to a minor folding-movement with approximately meridional axes.

It is also noted that, in New Caledonia, Triassic, Jurassic, and Cretaceous strata are apparently conformable, and have all been subject to subsequent overthrusting from the north-east. This strengthens the conclusion that the more important folding did not take place till after the deposition of the Cretaceous.

It appears, then, that there were transgressions in Triassic time (1) from the east, extending as far west as New Caledonia, and (2) from the south, forming the Gulf of Queensland. During Jurassic, the eastern coast remained in much the same position, the Gulf of Queensland disappeared or was very much reduced, and the sea transgressed in Western Australia parallel to the present western coast, and also in New Guinea to the Strickland River district; during this time, also, the extent of the basins,



Text-fig. 5.

Map showing the distribution of land and water in the Australasian Region in Jurassic time. (Solid black represents the present known extent of strata).

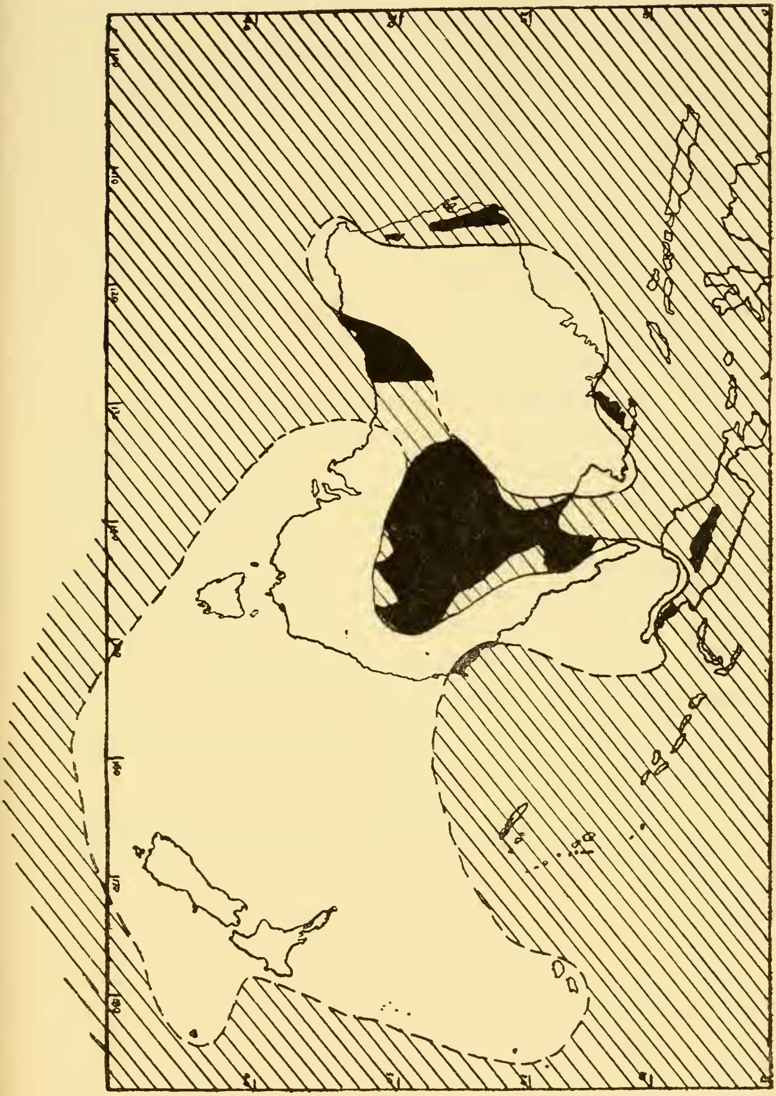
in which freshwater deposits were laid down, increased enormously. The early Cretaceous period saw very great changes in distribution of land and water. The sea transgressed from the north in the region of the Gulf of Carpentaria, at least as far as Lake Eyre; Australia appears to have been divided into two parts, either by the extension of this transgression to the south-west, or by meeting another from the south-west. These successive changes are shown on Text-figs.3-6.

Summary.

The Lower Mesozoic rocks of Queensland comprise three divisions, namely, the Ipswich, Bundamba, and Walloon Series. The Ipswich and Bundamba Series are of comparatively limited distribution, and are confined to the south-eastern portion of the State. The Walloon Series has a much greater extent; in addition to occurring in South-eastern Queensland, in association with the Ipswich and Bundamba Series, it outcrops in a belt along the western slope of the Main Divide from the New South Wales border to Cape York, dipping westerly beneath the marine Cretaceous. It probably underlies the Cretaceous strata over the greater part of Western Queensland. In Eastern Queensland, there are a number of small, isolated occurrences of the Walloon Series, as indicated on Plate i. The thicknesses of the three series are approximately as follows: Ipswich Series, 2,000-2,500 feet; Bundamba Series, 3,000-5,000 feet; and Walloon Series, up to 10,000 feet.

From an economic point of view, the Lower Mesozoic rocks are of special importance in three respects, namely, (1) the greater part of the coal produced in Queensland is from the coal-measures of the Ipswich and Walloon Series, chiefly the former; (2), the large supplies of artesian water are obtained from sandstones which are the equivalents of the Walloon Series in Western Queensland; (3) practically all the Queensland sandstone used for building purposes is of Lower Mesozoic age.

In South-eastern Queensland, the Lower Mesozoic rocks (and also the Cretaceous strata) have been folded into a series of anti-



Text-fig. 6.

Map showing the distribution of land and water in the Australasian Region in Lower Cretaceous time. (Solid black represents the present known extent of strata).

clines and synclines, whose axes are in a general N.30°W.-S.30°E. direction. This folding is sometimes severe, the strata having been fractured, the folding giving place to distinct faulting. The age of this folding and faulting is Post-Lower Cretaceous and Pre-Cainozoic; none of the Cainozoic rocks in south-eastern Queensland have been affected by it.

In the Ipswich district, Mr. Cameron has observed a subsequent folding-movement with approximately meridional axes; this latter folding has affected the Cainozoic sedimentary and volcanic rocks, as well as the Lower Mesozoic rocks.

In Western Queensland, the Mesozoic rocks have not been subject to folding-movements.

The Bundamba Series is practically devoid of fossils, but both the Ipswich and Walloon Series contain abundant plant-remains; there are also numerous fossil insects in the Ipswich Series. Examination of the fossil floras indicates clearly that the Ipswich Series must be regarded as Triassic in age, and the Walloon Series as Jurassic. The exact position of the Ipswich Series in the Triassic cannot be definitely fixed at present, but it seems certain that it is Upper Triassic, possibly Rhætic, but probably older. The flora of the Walloon Series corresponds, to almost equal extents, with Liassic and Lower Oolitic floras. This Series probably corresponds to a period covering these two epochs, and when the Walloon Series is known in greater detail, it may be possible to subdivide it accurately.

The exact position of the Bundamba Series in the Geological Record cannot be fixed, but it is suggested that it is more closely associated with the Ipswich Series than with the Walloon Series, and, therefore, it is tentatively placed in the Triassic.

A comparison of the Queensland Lower Mesozoic strata with other occurrences in Australia of similar age seems to show, (1) that the Narrabeen and Hawkesbury Sandstone Stages in New South Wales are older than the Ipswich Series; (2) that the Wianamatta Stage of the Hawkesbury Series in New South Wales, and also possibly part of the Lower Mesozoic strata of Tasmania are of the same age as the Ipswich Series; and (3) that the following series in the other States are of the same age as the Walloon Series: the Artesian Series, Clarence Series, and Talbragar Beds in New South Wales; the Jurassic strata of the South Gippsland, Cape Otway, and Wannon areas of Victoria; the Leigh's Creek beds in South Australia; part of the Lower Mesozoic strata of Tasmania; and the marine Jurassic series in Western Australia.

An account has been given of the probable geological history of Eastern Australia between the close of the Palæozoic era and the beginning of the Cretaceous period, and it is evident that the Lower Mesozoic rocks are, with a single exception, of freshwater origin. Their exact mode of origin is not definitely settled; it has been shown that the basins in which they were deposited must have had some outlet; deposition may then have been in inland lake-basins with a river-outlet, or the deposits may represent accumulations under fluviatile conditions.

The geological history of the area is illustrated by a series of palæogeographic maps of Australia and the South-western Pacific region, representing the probable distribution of land and water at different stages in Lower Mesozoic time.

EXPLANATION OF PLATES I.-II.

Plate i.

Map of Queensland showing the distribution of Lower Mesozoic rocks.

Plate ii.

Geological Sketch-Map of South-eastern Queensland showing the areas occupied by the Lower Mesozoic rocks.